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# Integration of Digital Twin Technology and Health Dialogues

- An Interface Design to Contribute to Motivation for Healthy Habits

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*Integration av tekniken "Digital Tvilling" och hälsosamtal*

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## Abstract

Around the world, people are becoming more sedentary and less physically active. These behaviors are two examples of habits causing lifestyle diseases and premature death. The Health Dialogue (*Hälsosamtal*) is a method used in Sweden today, which attempts to prevent people from being diagnosed with lifestyle caused diseases. Today, the Health Dialogue does not offer an opportunity to perform follow-up of lifestyle goals created during the Health Dialogue, which is an important missing piece of the method. Follow-up regarding goals can benefit from being combined with digital twin technology, since this type of technology can potentially prevent negative habits by providing personalized predictions of bodily functions. In this thesis, a design prototype was created, combining the Health Dialogue with digital twin technology as an attempt to increase motivation towards a healthier lifestyle. Three hypotheses were proposed and evaluated through a user test containing the created design prototype. The results of the evaluation showed some support for the hypotheses for some participants, but overall, not enough to show support for motivation while using the prototype. However, the design and evaluation method can help in further development of an application that might contribute to motivation of a healthier lifestyle in the future.

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# 1 Introduction

## 1.1 Motivation

The healthcare sector is facing many challenges, where an aging population and higher expectations are two examples [21]. To maintain a sustainable healthcare in the long term and to handle the challenges to come, an increased efficiency is needed, which is one of the key perspectives that the *Vision eHealth 2025* is operating on [21]. Vision eHealth 2025 states the following: “In 2025, Sweden will be best in the world at using the opportunities offered by digitisation and eHealth to make it easier for people to achieve good and equal health and welfare, and to develop and strengthen their own resources for increased independence and participation in the life of society.” [22]. The year 2025 is approaching, which means more well designed eHealth solutions are needed in the coming years in order to fulfill the vision and manage future challenges.

Lifestyle diseases are an example of a growing health issue. Lifestyle diseases are characterized by being caused by the daily habits of people [27], where poor food habits and low physical activity are two examples of lifestyle habits that are likely to cause disease [19]. There is an increasing trend that people are becoming more sedentary and less physically active [30]. In 2020, 25 % of the global adult population did not meet the recommended levels of physical activity [30]. Poor lifestyle habits have been shown to cause many health issues, which can lead to non-communicable diseases (NCDs) [27], which are the cause of 71 % of the deaths globally [29]. NCDs also usually require lengthy and expensive health care treatments [29]. Thus, both money and lives can be saved if the incidence of NCDs is decreased, which can be lowered through changing behaviors to gain healthier lifestyles.

New technologies have developed fast since the beginning of the century, with more smartphones, tablets and streaming services that are known to increase sedentary behavior. However, other new technologies, such as smartwatches, might instead decrease sedentary behavior, which could help solve the issue of lifestyle diseases. Personal wearable sensors (wearables) is a type of technology that has a growing popularity, that is not only used for increased activity. With the rise of personalized medicine, wearables in the medical field are also becoming more common [32]. At risk patients’ health status could be monitored by using wearables, which allows diseases to be predicted and prevented, and thereby decreasing healthcare costs [32]. Furthermore, collections of individual data collected from wearables

could be combined with mathematical models to provide more types of predictions compared to only monitoring. With mathematical models, changes in physiological systems over time can be described. Also, how various biomarkers behave can be simulated based on certain scenarios, such as certain lifestyle habits. Moreover, this combination of data and models can be used to create digital twins – personalized predictions of bodily functions.

Combining individual data with mathematical models to create digital twins is currently researched by the *SOUND Innovation Environment*. The digital twin can assist in fulfilling the potential *Precision Health*, which is grounded in the rapidly developing wearable sensor technologies, artificial intelligence, information sharing, and mathematical models. These factors have the potential to improve the healthcare system by making it more patient-centric, preventive and interconnected, while empowering the patients and offering more personalized prediction models, which can be summarized as Precision Health. The SOUND Innovation Environment has three main goals: 1) *Development of the digital twin technology*, 2) *Improved medical pedagogics* and 3) *Impact assessment*. Some people in the research group *ISB Group* at Linköping University are working towards achieving the goals of the SOUND Innovation Environment, and this thesis is made in collaboration with this research group.

An appropriate setting to use this type of digital twin technology is in Health Dialogues (*“Hälsosamtal”*). This is a method created to improve the health of Swedish citizens and to prevent lifestyle caused diseases. It is currently carried out in a small scale in Region Östergötland, where it is offered to a few individuals the year they turn 40, 50, 60 and 70 years old [23]. This method offers an evaluation of the health status using a tool called the Health Curve (*“Hälsokurvan”*). Based on the Health Curve, a health intervention is offered to those at risk for developing different diseases [23]. During a health intervention, a nurse motivates an individual to make positive lifestyle changes and helps set up goals [23]. Currently, there are 10 years between each Health Dialogue for each individual. During those 10 years, these people usually get no further help to fulfill their health goals but are instead left to attempt a lifestyle change on their own. For the method to be more effective long term, a tool for individuals to follow up on the goals created during the Health Dialogue is needed. This tool needs to motivate the individuals to perform actions that will lead to a healthier lifestyle in order to fulfill the goal of preventing lifestyle caused diseases.

## 1.2 Aim

This thesis aims to present a possible design interface for follow-up of the Health Dialogue. The target group of the design is Swedish inhabitants between 40 and 80 years that have performed a Health Dialogue and want help regarding motivation for a healthy lifestyle.

## 1.3 Research Question

The definition of motivation will be based on the Self-Determination Theory, where the motivation is said to be determined depending on the extent to which the three concepts *autonomy*, *competence*, and *relatedness* are met [16]. According to Kilpatrick, Hebert, and Jacobsen, autonomy can be described as an individual having internal control and being free to choose their own actions [8]. Competence can be described as the feeling of knowledge and understanding, and the perception of being effective [8]. Finally, relatedness can be described as feeling fulfillment or engagement in the community [8]. Hence, the research question is as follows:

**Can an interface design using digital twin technology in combination with the Health Curve be designed to fulfill autonomy, competence, and relatedness of the user, and thereby contribute to motivation towards a healthier lifestyle?**

## **1.4 Delimitations**

The final prototype will be a conceptual interface design to evaluate design and functionality using test users of the target group, which will give a proposed design for a final solution. Therefore, the prototype itself will not function as a final product. The target group of the final system is described in the aim, but in this thesis the target group for evaluation of the design prototype is instead all people living in Sweden between ages 40 and 80. Also, there are many aspects of health, but the literature in this thesis will primarily be focused on physical activity.



## 2 Theory

### 2.1 Swedish People and the Internet

In the third quarter of 2020, 73 % of internet users had used some digital service within the healthcare (eHealth service), such as replacing a physical appointment with a healthcare application, seeing their recipes online, or seeing test results online [26]. There are several noticeable differences where the background profile seemed to affect the proportion of people that have used an eHealth service in late 2020. Some background profiles are presented in Table 2.1, where the groupings overlap and some people are present in several categories.

Many people living in Sweden are foreign-born due to immigration from other countries, which make up a large part of the category “Born outside Scandinavia”. Specifically, in December 2020, 19.7 % of the Swedish population were foreign-born [24]. This means that the design solutions in health care tools need to consider people with other cultural backgrounds and languages than Swedish to be inclusive of all people living in Sweden. From the statistics shown in Table 2.1, people born outside Scandinavia have used any eHealth service to the same extent as the average internet user in Sweden, which indicates that the current Swedish eHealth design solutions are adapted to language and cultural differences.

It is well known that unfavorable habits are more common among people who has a lower socioeconomic status than those with a higher one. This difference seems to reoccur when measuring either occupational status, income size or level of education, according to Kristenson [10]. The differences also follow a gradient, which means that the lower socioeconomic status, the worse health a person usually has [10]. This in combination with people in Sweden who has a lower socioeconomic status being less frequent users of eHealth services, leads to it being harder to reach the people that needs help the most through digital services.

There are also slight differences in usage of digital health services related to age. Before the covid-19 pandemic, 1 % of the population (16 years or older) in Sweden did not use the internet [26]. As a result of the covid-19 pandemic, among the elderly people in this percentage (76 years or older), more have started to use the internet to for example contact relatives through video calls [26]. Table 2.2 presents the percentage of several age categories that have used the internet and at least one eHealth service in the third quarter of 2020.



Table 2.1: Percentage of different background profiles in Sweden that have used any eHealth service in the third quarter of 2020 [26]. The yellow color represents the average percentage for the average internet user, while green represents higher percentage than the average. Instead, the red color indicates that the percentage is lower than the average.

Background Profile	Percentage
Low income household (-300k sek)	73 %
High income household (750k+ sek)	79 %
Primary school education	56 %
Higher education	81 %
Countryside	67 %
City	78 %
Man	67 %
Woman	79 %
Born outside Scandinavia	73 %
Average internet user (16+ years)	73 %

Table 2.2: Percentage of different ages in Sweden that have used any eHealth service in the third quarter of 2020 [26].

Age	Percentage
36-45	83 %
46-55	74 %
56-65	70 %
66-75	68 %
76+	67 %

## 2.2 Physical Activity Guidelines

The Public Health Agency of Sweden (Folkhälsomyndigheten, FHM), which provides health recommendations in Sweden, base their guidelines for physical activity and sedentary on the 2020 WHO Guidelines on physical activity and sedentary behavior [4]. WHO state that 25 % of all adults do not meet their recommendations, and that up to 5 million deaths could have been averted if the population of the world was more active [30].

In the WHO guidelines, it is recommended for adults (18-64 years) to be regularly physically active [31]. More specifically, adults should on a weekly basis perform 150-300 minutes of aerobic physical activity of moderate-intensity, or 75-150 minutes of vigorous-intensity, or an equivalent combination of the different intensity level [31]. In addition, adults are recommended to perform muscle-strengthening activities that include all major muscle groups at least on two days each week, at moderate or greater intensity [31]. Adults may also increase aerobic physical activity to more than 300 minutes at moderate-intensity or more than 150 at vigorous-intensity a week, or a combination of the two intensities [31]. The recommendations for older adults (65 years and older) are the same as for adults, but with additional varied multicomponent physical activity [31]. This activity should include balance and strength training at moderate or greater intensity, on at least three days of the week, which helps prevent falls and enhance functional capacity [31].

## 2.3 Self-Determination Theory

The self-determination theory is a theoretical model, developed by Ryan and Deci, and is based on three universal human needs: *autonomy*, *competence*, and *relatedness* [16]. According to Kilpatrick, Hebert, and Jacobsen, is autonomy characterized by an individual having internal control and the perception of freely choosing their own actions [8]. Competence is

instead characterized by the feeling of knowledge and understanding and the perception of being effective [8]. Finally, relatedness is characterized by fulfillment and engagement in the community [8]. The self-determination theory suggests that all individuals feel a desire to satisfy these three needs and that this desire leads to actions that can fulfill them [8]. Exercising and participating in sports can be one way to meet these needs, and depending on the extent to which the needs are met, the individual is said to have a certain motivational state, depending on the motivation type [8]. The theory can also be applied to different areas than physical activity and be used to understand motivation toward different behaviors [8].

The self-determination theory includes three types of motivation, namely *amotivation*, *extrinsic motivation*, and *intrinsic motivation*, which are placed on a continuum going from amotivation, which is said to be nonself-determined behavior, to intrinsic motivation, which is said to be self-determined behavior [16]. In the middle of the continuum is extrinsic behavior, which Ryan and Deci suggest have four different types of regulatory styles, which are *external*, *introjected*, *identified*, and *integrated* [16]. The regulatory process along with perceived locus of causality and regulatory style for these three main types of motivation are presented in table 2.3. Kilpatrick, Hebert, and Jacobsen state that an individual can move from one level to another in both directions, which can cause the adherence to activity and sport to change [8]. They also state that the adherence changes when the motivation changes, which is enhanced or undermined by different behavioral factors [8]. The different types of motivation will be explained in more detail in the next paragraphs.

Table 2.3: Self-determination types of motivation and their regulatory styles, perceived locus of causality, and regulatory process, compiled from [16].

Motivation	Regulatory Styles	Perceived Locus of Causality	Regulatory Process
<b>Intrinsic Motivation</b>	Intrinsic regulation	Internal	Interest, enjoyment, inherent satisfaction
<b>Extrinsic Motivation</b>	Integrated regulation	Internal	Congruence, awareness, synthesis with self
	Identified regulation	Somewhat internal	Personal importance, conscious valuing
	Introjected regulation	Somewhat external	Self-control, ego-involvement, internal rewards and punishments
	External regulation	External	Compliance, external rewards and punishment
<b>Amotivation</b>	Non-Regulation	Impersonal	Non-intentional, non-valuing, incompetence, lack of control

### 2.3.1 Intrinsic Motivation

At the intrinsic motivation level, the individual chooses freely to engage in an activity based on desire to perform the activity itself and is intrinsically motivated by the activity resulting in excitement, enjoyment, or challenge, which are all motivations without any external reward or benefit [8]. Research shows that intrinsically motivated individuals are more likely to believe in and follow the practices of physical activity [8]. Additionally, research suggests that sports is more related to intrinsic motivation such as enjoyment and satisfaction, and exercise in general is related to both intrinsic and extrinsic motivation and tend to be more related to health and fitness motives [8].

### 2.3.2 Self-Determined Extrinsic Motivation

This level is characterized by the individual performing an activity based on the desires of the outcome of the activity, such as socializing, improving, and maintaining fitness and body relaxation, instead of the activity itself [8]. These motivations are also desirable since they are self-determined by the individual and freely chosen [8].

### 2.3.3 Other-Determined Extrinsic Motivation

Motivation that is other-determined is not considered desirable, since the motivation is based on rewards, guilt, fear, and obligation [8]. These types of motivation do not lead to an autonomous individual, since they can be considered to control the behavior of the individual, which can lead to decreased perception of free choice and control [8]. Research indicates that other-determined extrinsic motivation causes the individual to be less likely to adhere to the activity, as well as decreased frequency of the activity, compared to if an individual is self-determined extrinsically motivated [8].

### 2.3.4 Amotivation

At the lowest level on the continuum is amotivation, where individuals at this level lack the organized motivation to be physically active [8]. This can be due to believing that activity will not have any effect and lead to any desired outcome, nor help them to experience autonomy, competence or relatedness [8]. Usually, the motivation for these individuals does not exist due to poor self-image, poor image of activity, lack of time and interest, or lack of knowledge about activity, which ultimately results in the individual being very unlikely to adhere to activity [8].

### 2.3.5 Strategies for Increased Participation

There are some recommendations to increase the adherence to physical activity that can be used by practitioners, which are listed below: [8].

- *Giving positive feedback* - Positive feedback about a performance aspect helps the participant to develop self-confidence and competence, instead of negative feedback, which can decrease the self-esteem and perceived competence.
- *Promoting process goals* - Goals that allow improvement to be a successful measurement help the participant to be autonomous by focusing on improvement of the task, instead of performance of the task, which can result in pressure and reduced effort.
- *Promoting Moderately Difficult Goals* - Goals between “too easy” and “too hard” support the competence and mastery development, whereas too difficult goals decreases the perceived competence and increases the likelihood to fail.
- *Providing Choice of Activities* - By presenting several activities to choose from, the participant satisfaction and autonomy is developed, while requirement of an activity might result in perceived pressure and decreased autonomy.
- *Providing a Rationale for Activities* - If a brief description of why the activity has been selected, the autonomy development is supported, and it reduces the sense of pressure.
- *Promoting the Development of Social Relationships* - Encouraging social connections helps development of social relationships in a physical activity context, which facilitates development of relatedness, social satisfaction and enjoyment.

- *Utilizing Rewards Carefully and Sparingly* - Using rewards only when developing new behaviors for a short period of time, instead of to sustain existing behaviors is beneficial, since rewards can impair the motivation and create a sense of pressure and coercion.

## 2.4 Psychological Design

Bodestad and Brohede have defined the concept *psychological design* [2], and an attempt of translating their definition results in the following definition: *a deliberate design of treatment, prevention and health promotion interventions, based on psychological principles and research*. Psychological design is then said to be needed due to increased need for flexibility in format of different treatments, and because caregivers do not have time or resources to perform inefficient treatment programs [2]. Too often, hasty assumptions of humans in these types of programs are made, which results in inefficient design of the digital support and treatment programs [2].

Three examples of pitfalls that are common when creating these programs related to change of behavior, are that: 1) information can be sufficient, 2) the program is not encouraging intrinsic motivation, and 3) the patient has great willpower [2]. These are the main pitfalls with digital design in treatment programs, and Bodestad and Brohede describe three principles that can be used when designing programs: 1) design for emotion and intellect, 2) design for autonomy, competence and relatedness, and 3) design for habit.

### Principle 1: Design for Emotion and Intellect

The first principle relates to the first pitfall, which can be described by understanding the split between the intellectual part, and the emotional part of the human [2]. Usually when believing that information will be sufficient to make a change in behavior, the intellectual part gets too much credit. To actually make a change, the emotional part needs to be convinced. Therefore, it is important to consider the emotions and design for this, since this is the part that can trigger action according to Bodestad and Brohede [2]. Still, it is important that the patient understands the situation and gets enough information, which is why the design must be appealing to both the intellect and the inner emotional drive [2].

Some examples of ways to design for emotion are to use social proof, shorten the path to the goal, and lastly, to design with shorter goal time spans [2]. First, by using social proof, other people can be used as influence factors for behavior change [2]. Second, when the path to the goal is shortened, it helps to achieve early success, which can facilitate motivational drive to continue with the task, and then later be motivated to handle more difficult tasks [2]. Finally, if the goal has a shorter time span, the person fulfill the task to a higher extent, as well as having a greater desire to perform the task, than if a longer, for example a 10-year, plan was made [2].

### Principle 2: Design for Competence, Relatedness and Autonomy

From the self-determination theory, previously described, the importance of intrinsic motivation connected to adherence to an activity was presented. Bodestad and Brohede suggest that intrinsic motivation is necessary to help people find and use their inner driving force. As stated earlier, the three main needs of the human connected to the intrinsic motivation are autonomy, competence, and relatedness, which is why these need to be in focus in order to create a more successful patient program [2].

The programs should thereby be designed so that patients perceive they are competent, self-determined and belong to a social content [2]. This can be performed by for example encouraging experimenting or making individual adaptations based on the driving force of the patient [2]. Another way to help perceive these needs is to use techniques from the method

*motivational interviewing*, which especially helps perceive autonomy [2]. Furthermore, the autonomy can be triggered by designing in a way that allows the patient to choose their own path from different alternatives, instead of having a linear path of tasks [2]. Additionally, visualizing the progression of the patient can also help the intrinsic motivation, where it can be beneficial to take ideas from the concept *gamification* [2]. Finally, designing so that social interactions are used in the program, by for example sharing their progress with others, the intrinsic motivation can be helped by feeling support and relatedness to people in similar situations [2]. These five suggestions of designing can help to motivate the patient intrinsically, which then helps him or her fulfill the goals of the program.

### Principle 3: Design for Habit

It is said that 40 % of everything a person does on a regular day, is done out of habit to save mental energy, according to Bodestad and Brohede [2]. Therefore, changing a behavior is more effective and resource saving when working with tuning existing habits [2]. However, often when attempting to change, start or end a habit, it fails due to the optimistic belief of human discipline, character, and self-control [2], which is one of the common pitfalls previously mentioned. The Fogg model presented by Bodestad and Brohede illustrate the relationship between motivation and ability, where lower motivation requires higher ability to succeed with a prompt [2]. Instead, if the motivation is higher, the ability does not have to be as high to succeed with the prompt.

To be able to change a behavior, either the motivation, ability or prompt needs to change [2]. Out of these three, motivation is the hardest to affect, but the ability can instead be easier to influence, which is about the possibilities of a person to perform the wanted behavior [2]. If the wanted behavior, or prompt, is too difficult or too far away from what the person is able to do today, then the motivation will decrease as the person gains insight regarding the difficulty of the behavior in relation to the ability of the person. For example, if the wanted behavior is to run 10 kilometers every day, and the person can only run 1 kilometer at a time now, then the ability to perform the wanted behavior is very low. Therefore, the Fogg model can explain why many attempts to change a behavior fail [2]. The more demanding the prompt, the more motivation and higher ability is needed to succeed with the prompt, which is why a change in behavior should, according to this model, start in a smaller scale [2]. Starting small helps to create the new behavior, and helps with early success, and eventually the scale increases as the ability increases [2]. Therefore, designing programs in a playful and exploring way for early success, and focusing on a reasonable and long term behavior based on the current ability, are tools to avoid the pitfall number three [2].

## 2.5 Universal Design

According to Story, there are many different definitions and alternative names for universal design, but the main concept stays the same: an accessible and usable world for a diverse population [25]. Vision eHealth 2025 describes a vision and a strategy where digital services that are used in healthcare should be universally designed with consideration for all people, regardless of previous knowledge and experiences and without special adaptations, and no one should be discriminated against [21]. A specific definition for universal design by *The Center for Universal Design at North Carolina State University* is “the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design” [25]. In 1997, The Center for Universal Design then developed a set of universal design guidelines called *Principles of Universal Design* with the goal to assist designers and consumers to understand characteristics of more usable design solutions [25]. The seven principles are called the following: 1) *Equitable Use*, 2) *Flexibility in Use*, 3) *Simple and Intuitive Use*, 4) *Perceptible Information*, 5) *Tolerance for Error*, 6) *Low Physical*

*Effort*, and 7) *Size and Space for Approach and Use* [25]. For further insight on these principles, the source can be used.

## 2.6 Design Process

Bodestad and Brohede have created a design process for psychological design, which is based on the design process *the double diamond*. Their design process has five main phases, where an attempt to translate these are the following: *project frames*, *understand*, *design*, *produce*, and *introduce* [2]. These phases form the foundation on which this thesis method is made from.

The project frames set the prerequisites for the design and implementation of the project [2]. In relation to this thesis, the project frames are set in the goal and research question in Chapter 1. The goal with the understand phase is to gain knowledge about the user group through research about them and contact with them [2]. During the design phase, assumptions about the user from the previous understand phase are used to develop the design [2]. By continuously involving the users throughout the design process it can help reassure that the assumptions are correct, and the purpose of the product can be fulfilled [2]. In the produce phase, the material and information is produced, which is usually done in sprints with the main goal divided into sub-goals [2]. In the final phase, introduce, the program is implemented into existing work routines in a certain operation [2]. The produce and introduce phase will not be considered further, since this thesis is focused on the design phase, and will not produce and introduce any product.

## 2.7 Likert-Scale Questionnaires

A Likert-scale is psychometric and the respondents of such a questionnaire can choose from different categories to express their opinions, feelings, or attitudes about a certain issue, according to Nemoto and Beglar [13]. Likert-scale questionnaires are most common to use when measuring psychological constructs, such as motivation, and have the advantage of being able to gather much data in a relatively short active time [13]. Short surveys using the Likert-scale usually have a higher number of participants in relation to the number of people surveyed, compared to longer and more complicated surveys, according to Sataloff and Vontela [18]. Nemoto and Beglar divide the development process of Likert-scale questionnaires into five main steps: 1) *understand the construct*, 2) *develop the items*, 3) *determine the outcome space*, 4) *specify the measurement model*, and 5) *gather feedback and pilot questionnaire* [13].

The first step, understanding the construct, is primarily done by reading academic literature, which is needed in order to develop the items [13]. The items are concrete realizations of the construct and should measure a specific aspect of the abstract construct [13]. When developing the items in the second step, each item should represent one idea and be written in non-technical, easy-to-understand language, preferably in the respondents' native language [13]. Furthermore, each item should have different levels of difficulty, ranging from *easy to endorse* to *difficult to endorse* [13].

In the third step, a limited range of possible answers are created, usually 6 possibilities, which make up the outcome space through a 6-point scale [13]. A 6-point scale is preferable to enable increased precision of measurement, while there still being a distinct difference between the points according to Nemoto and Beglar [13]. Also, it is preferable according to Nemoto and Beglar that there is no *neutral* option, since this option can disturb the measurements by not fitting into the models and being unnecessary since the respondents should be able to answer the questions [13].

## 2.8 Survey Quality Evaluation

There are different metrics that can be used to evaluate the quality of a survey, for example response rates and bias. A basic definition of response rate is the number of completed surveys divided by the number of people surveyed [14]. This number can then be multiplied with 100 to give a percentage for the response rate, where an increased response rate results in increased quality. Sataloff and Vontela state that a low response rate leads to decreased sampling size and power of the study, as well as increased potential bias [18]. A bias that can arise from low response rates is the nonresponse bias, which is more significant when there is a larger difference between the respondents and the nonrespondents due to misrepresentation of the surveyed group [18]. Sampling error is another bias that occurs when a nonrepresentative survey group is chosen [18].

As response rate is a widely used metric to set a limit for accepted publication of survey-based research, Sataloff and Vontela state that papers can still report important findings despite low response rates. For example, they can still be of importance if the sample size is large, or if the survey results can inspire future research [18]. Additionally, they suggest that response rates should be reported, potential nonresponse bias should be acknowledged, and a critical review should be performed regarding whether the strengths outweigh the low response rates [18].

## 2.9 Related Work

Interventions of health can take different forms and have evolved quite rapidly during the last 20 years, especially since internet interventions are becoming more popular. The effectiveness of cell phones for health information interventions and disease management has been studied by Krishna, Boren, and Balas in 2009 [9]. In this study, published studies about using cell phones and short message service (SMS) for care, were systematically reviewed [9]. Moreover, the study resulted in a set of 25 studies including 38 060 participants which had an average study duration of 6 months and included 12 different clinical areas [9]. These areas were grouped together based on the outcome of the study; one group with the outcome *behavior change* included the following topics: HIV/AIDS, diabetes, smoking cessation, physical activity, blood pressure and hepatitis vaccination [9]. In 80 % of the studies, in the topics mentioned, a change in behavior was reported as a result of an informational intervention delivered to the cell phones of the participants, using either voice or SMS [9]. The authors define behavior change as “*an action taken that has been documented to lead to better health outcomes*” [9]. The result of this study shows that an eHealth solution, such as a cell phone service with an informational intervention, could lead to behavior change of individuals in a clinical setting.

Another similar area, which relates to health information interventions, is studied by Sandborg, Henriksson, Larsen, *et al.*, where the project HealthyMoms conducted a long term study (six months) of pregnant women using a mobile application to help maintain or improve healthy habits and have a healthy weight gain [17]. The participants were instructed to register dietary intake and wear an accelerometer to report physical activity, which was then assessed [17]. The results showed a main theme, and two subthemes, where the main theme was “One could suit many: a multifunctional tool to strengthen women’s health during pregnancy”. One subtheme was “Factors Within and Beyond the App Influence App Engagement” and the second subtheme was “Trust, Knowledge, and Awareness: Aspects That Can Motivate Healthy Habits” [17]. They observed that the HealthyMoms application was appreciated by pregnant women and likely to benefit them, and that several positive and negative factors of the app and the environment affected the engagement of the app [17]. Although the HealthyMoms app is somewhat individualized, using a digital twin could potentially provide an even more personalized experience and individualized presentation of data.

Digital twins of humans in healthcare are researched in several different ways today. For example, three subtypes of a digital twin have been developed by Lutze, where they are applied to use cases in healthcare [11]. One of the subtypes is a *personal digital twin* that, in principle, can map measured sequences of data from wearables to activities of daily living, and compute a probability value of how positive or negative the activity is [11]. However, the target group of this research is the elderly and/or people in need of care [11], and the subtypes of twins are not actually developed. Another example is the *health avatar*, where the idea is that wearables generate data, following data processing that results in a health avatar. The avatar represents an electronic version of a person with the goal to improve personal health quality [12]. However, this research is still merely an idea instead of a completed product at this time.

There is some research with focus on digital twins in preventive healthcare, although these are often speculations instead of actual solutions. El Saddik mentions that only the imaginations sets the limit of the applications of a digital twin [3]. He states that by using AI, patterns in the lifestyle could be recognized and used to predict possible issues regarding the health [3]. Also, diseases, such as strokes, could be predicted and therefore possible prevented [3]. Furthermore, the digital twin could help improve health by customized health recommendations, such as reducing stress through recognizing patterns of stressful situations and providing help regarding how to avoid them [3]. Another helpful aspect of the digital twin is its power to motivate, since it could provide projections of the individual in the future, showing the result if the person continues with a certain lifestyle – both poor and good [3]. In conclusion, a digital twin can in theory help predict and prevent health issues, diseases and stress, as well as help motivate to make good lifestyle choices. However, to the best of my knowledge, no product with digital twin technology including the entire body is on the market yet.

Even though no product can create a personal digital twin with data from wearables yet, there are cases where healthcare clinics provide wearable sensor technology to patients for monitoring, in order to improve care and encourage independent living [15]. This type of monitoring can detect some health issues, such as heart arrhythmia [15], which strengthens the personal care of the patients. However, the predictions of diseases and health issues are limited with this type of monitoring, compared to what a personal digital twin could predict.

As mentioned in Section 1.1, the SOUND Innovation Environment work with the concept Precision Health, where Herrgårdh, Madai, Kelleher, *et al.* are some of the people working to fulfill this potential. They are the first to propose new concrete approaches combining machine learning, bioinformatic network models and mechanistic models to realize Precision Medicine of stroke [6]. With these combinations of models, called hybrid models, developing of personalized models in digital twins is possible [6]. As other research has concluded, these digital twins can be useful in various ways in healthcare. Examples of uses mentioned by Herrgårdh, Madai, Kelleher, *et al.* are to help patients regarding motivation to follow prescribed treatment, inspiration to perform preventative measures, and help medical doctors to create a more personalized treatment plan [6].

Another area the SOUND Innovation Environment is working on regarding digital twin technology is predicting diet response, both before and after long-term fasting. Silfvergren, Simonsson, Ekstedt, *et al.* present a tool that can predict non-measured variables for any diet using a novel mathematical model [20]. The model is developed and trained using four clinical studies, and it can predict personalized responses [20]. This extended model describes mechanisms regulating diet-response and fasting metabolic fluxes and can predict the impact of dietary compositions and fasting schedules [20]. This makes up a new type of digital twin technology that can for example help with compliance in patients [20]. Compliance can increase since seeing your own digital twin improve or loose metabolic function as a result of a diet is likely to increase motivation for a healthy diet [20].



To sum up, digital twins in healthcare are widely researched today, although no product can perform all predicted possibilities yet. The SOUND Innovation Environment has come further than anyone else in their development on digital twin technology of the whole human body. Their models will be used as foundation when deciding the functionality to present in the design interface of this thesis, which is combined with the concept of an internet intervention to increase adherence to healthy habits.

## 3 Method

The method of this thesis primarily uses the understand and design phase of the design process described in Section 2.6. To clarify what is desired to understand, this phase is called *user insight*. Chapter 2 creates a foundation for understanding the target group, and the results from the user insight phase are based on this understanding. The second phase is called *design*. To be able to evaluate the design and answer the research question, a new, third phase called *evaluation* was also added, which was not part of the design process described in Section 2.6. The three phases are presented in Figure 3.1.

This thesis was made in collaboration with the ISB Group, mentioned in Section 1.1. A subgroup of the ISB Group was acting as an expert group during the user insight and design phase of this thesis. This expert group consisted of an experienced programmer, a licensed medical doctor, a final year medical doctor student, and the research director of the ISB Group, Gunnar Cedersund. For the remaining part of the thesis, the ISB Group will be referred to as the “research group”, and the subgroup as the “expert group”.

In the first phase (Figure 3.2), insight about user expectations and desires was collected by brainstorming with the expert group. This insight in combination with the information from Chapter 2 was used to create personas and user stories. The user stories were used when performing a workshop to generate design ideas. During the second phase (Figure 3.3), the design was created through three iterations, where each iteration included the three steps: plan, design and evaluate. The third phase (Figure 3.4) evaluated the design through a user test. The evaluation was performed to investigate whether the design could fulfill autonomy, competence and relatedness, and thereby answer the research question.



Figure 3.1: Overview of the method.



Figure 3.2: Phase 1 of the method – User insight.

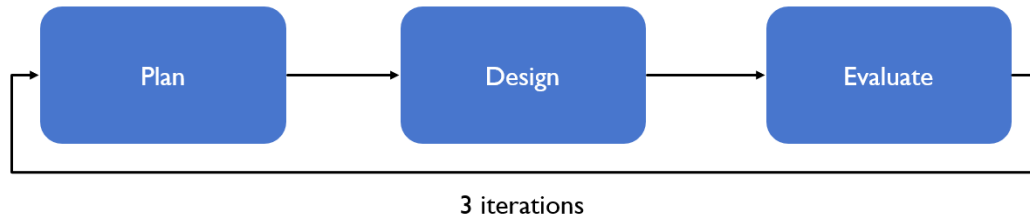


Figure 3.3: Phase 2 of the method – Design.

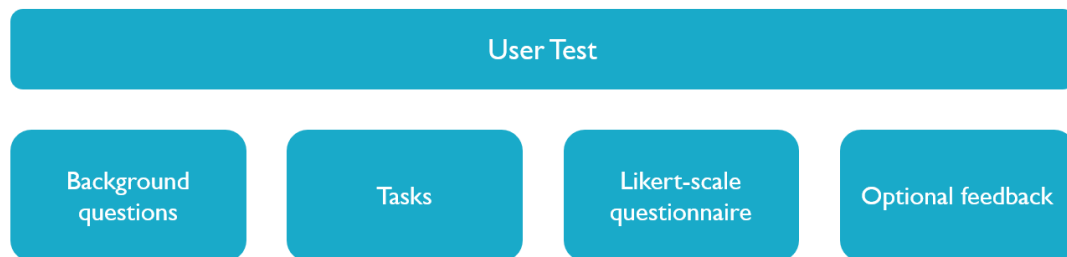


Figure 3.4: Phase 3 of the method – Evaluate.

### 3.1 User Insight

#### 3.1.1 Brainstorming

A brainstorming session was performed by the expert group. During this session, for the first 30 minutes, the members presented ideas on content, suggestions of presentation and wanted functions. These ideas were written down, and then for the remaining 40 minutes, these ideas were discussed, one by one. During discussion, new ideas, questions, and thoughts emerged, which were also written down.

#### 3.1.2 Personas

Based on the literature read during the first phase, three initial personas were made. These have different types of motivation and their physical activity and food habits vary, as well as their age and gender, to create as broad a user group as possible. These personas are used in the user stories to ensure that the user remains central in the functions created and throughout the design process.

#### 3.1.3 User Stories

The user stories contain statements about the functionality of the intended system with the format “*Persona X* wants/needs to ... so that ...”, where a certain persona’s wants or needs, and the reasons for them are stated. The stories create a basis for the functions that were designed.

### 3.1.4 Workshop

A workshop session was performed, where members of the research group sketched paper prototypes of the design, based on the user stories. The members were divided into 6 groups, with 2-3 people in each group. Paper, colored pens, scissors and post-it-notes were available for the design creation. Each group sketched a certain user story for 20 minutes, and then handed all papers over to another group who continued their sketch for 10 minutes. Then, all material was collected through pictures of the design idea and handing in all papers. Members participating digitally sent a screenshot of their design idea. In a second phase of the workshop, there was a presentation and discussion of the ideas sketched in the first phase. This led to clarifications in the sketches and additional information about the design.

## 3.2 Design

The design process followed an agile approach, which is an iterative and incremental work process that is both cost and time efficient, according to Tiwari, Rathore, and Gupta [28]. Bodestad and Brohede also state that an iterative approach by evaluating and reforming the design help create a better, cheaper and more time efficient design [2]. Based on this, the design was done in three iterations, where the first one resulted in a basic design idea. The third and last iteration was instead a more extensive and elaborate design more similar to a final system that could be created by the research group in the future. All designs were created using Adobe XD [1], which is a tool used for designing prototypes.

For each iteration, there were three main steps: 1) plan, 2) design, and 3) evaluate. In the planning step, overall goals were set for the iteration, and the functions to be designed were decided. In the design step, the planned functions were designed. Since an agile approach was followed, the plans for functionality were changed as appropriate. The last step was to evaluate the design with the help of the expert group by presenting the design and discussing strengths and weaknesses with the interface design. The evaluation discussions were considered during the planning part of the following iteration.

There are many guidelines that can facilitate when creating a new product, and for this thesis, guidelines regarding universal design and the design process were considered in the method. These concepts are described in Section 2.5 and 2.6. The Vision eHealth 2025 states that digital services used in healthcare are to be universally designed, and the resulting design of the thesis is a part of the process of incorporating the digital twin to the Swedish Health Dialogue. Therefore, five of the seven Principles of Universal Design (described in Section 2.5) were considered in the design process. Two were not considered due to them consisting of requirements about the physical environment, which is not something that can be affected through the interface design. Based on the common pitfalls when designing programs related to change of behavior mentioned previously in Chapter 2, the three principles of design and how to avoid these were also taken into consideration during the design phase.

## 3.3 Evaluation

Evaluation of the design was performed using Google Forms [5]. The form created will be referred to as the *user test* for the remaining part of the thesis and is found in Appendix A. An overview of the user test is presented in Figure 3.5. Since more than 80 % of the Swedish population is born in Sweden and the design prototype is in Swedish, the user test was also conducted in Swedish. The first part of the user test contains the following three background questions: biological gender, last completed education and age. The second part urges the user to perform tasks while using the design prototype. The second part also provides questions regarding the success of each task and an image to help determine when each task has been completed. The third part contains a Likert-scale questionnaire, and the fourth contains

an optional text field where feedback can be submitted. The user test investigated the ability to provide motivation to the user when using the prototype based on the concepts autonomy, competence and relatedness, which are the main concepts in the research question.

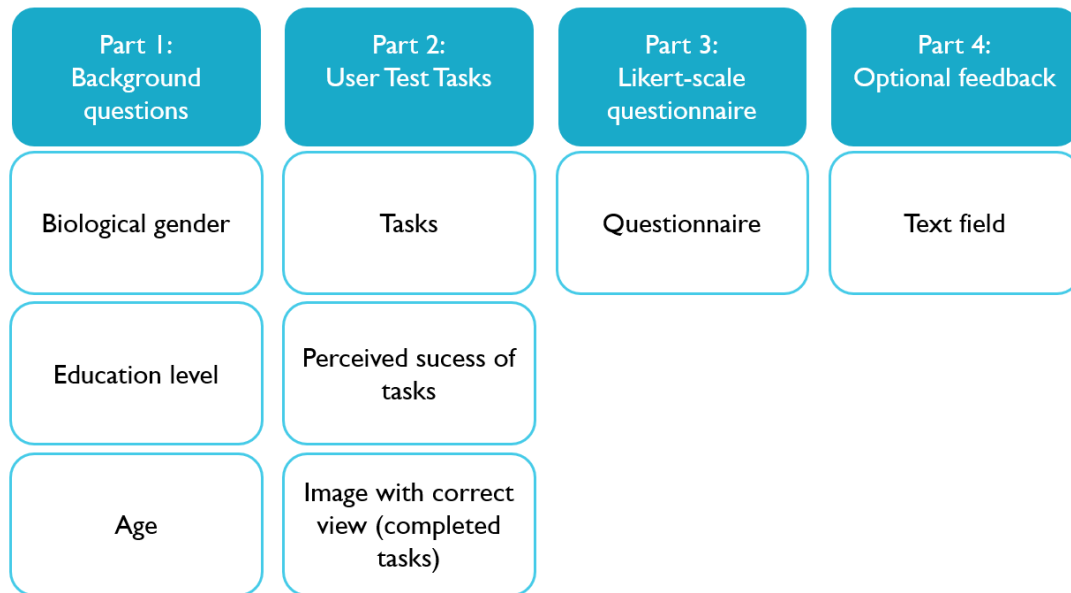


Figure 3.5: Overview of the user test.

### 3.3.1 Tasks

The tasks performed by the user test participants, translated to English, are the following:

1. Investigate what options are available on the home page
2. Look at the Health Curve
3. See more information about physical activity
4. Choose to see what has happened in the heart during a walk (the play button does not work in this prototype)
5. See more information about the minutes you have been physically active
6. See what friends have written in the flow
7. See what alternatives exist when you try to react to a post

There were three options for the participants to choose from after performing a task, where the participants were urged to choose one that best matched the task. Translated to English, the options were the following:

- I completed the task on the first attempt
- I completed the task after a few attempts
- I could not complete the task

### 3.3.2 Likert-Scale Questionnaire

The Likert-scale part of the user test was based on the Likert-scale questionnaire steps described in Section 2.7 focusing on the construct, items, and outcome space. The construct of interest for this questionnaire, considering the research question, was *motivation*. Section 2.3, and 2.4 resulted in an understanding of the construct motivation. The second and third step of the Likert-scale questionnaire model are to create items and an outcome space, which are now defined for this thesis.

#### Item Development

According to the self-determination theory, described in Section 2.3, motivation for physical activity is influenced by the human need for autonomy, competence, and relatedness. The more these needs are satisfied when performing an activity, the more motivated a person feels to continue to perform it. Based on these findings of motivation, the hypotheses in Table 3.1 were made for the target group, regarding the developed prototype.

Table 3.1: Hypotheses of the prototype's intended outcome, where a hypothesis code is connected to a hypothesis description.

Hypothesis code	Hypothesis Description
H1	When using the prototype, the user perceives they are autonomous
H2	When using the prototype, the user perceives they are competent
H3	When using the prototype, the user perceives relatedness

Taking the hypotheses into consideration, items were created and divided into two different types of difficulty levels based on the difficulty to endorse the statement in the item. For each hypothesis, four items were created with two that were expected to be easy to endorse (a-items), and two that were expected to be hard to endorse (b-items). An English translated version of the items for hypothesis 1, 2 and 3 are found in Table 3.2, 3.3, and 3.4, respectively. If the hypotheses are correct, the respondents should find it easier to endorse feelings of autonomy, competence and relatedness, and therefore more strongly agree with the a-items, compared to the b-items. In the user test, the items were mixed and the respondents neither knew the different level of endorsement for the items, nor the hypothesis related to each item.

Table 3.2: Items in Likert-scale questionnaire that are related to H1.

Expected Endorsement Level	Item
Easy	1a. When using the prototype, I feel like I get to decide what change in my lifestyle I should work on.
Hard	1b. When using the prototype, I feel like someone else decides what change in my lifestyle I should work on.
Easy	2a. When using the prototype, I feel like I can decide how to make a change regarding my lifestyle.
Hard	2b. When using the prototype, I feel like someone else decides how to make a change regarding my lifestyle.

The scale used to determine endorsement is shown in Table 3.5 (English version) and Table 3.6 (Swedish version). To deduct individual scores from the Likert-scale questionnaire, the grading shown in Table 3.7 was used. Since there are four items for each hypothesis, a maximum total score of 12 can be given for each hypothesis, and a minimum of -12. For the total score, the maximum is consequently 36 and the minimum is -36. A higher score for each hypothesis means that the hypothesis is supported.

Table 3.3: Items in Likert-scale questionnaire that are related to H2.

Expected Endorsement Level	Item
Easy	3a. When using the prototype, I understand how to use the presented tools.
Hard	3b. When using the prototype, I have a hard time knowing how to use the presented tools.
Easy	4a. When using the prototype, I feel like I can get help from the tools in it to change something in my lifestyle.
Hard	4b. When using the prototype, I have a hard time imagining that the presented tools can help me to change something in my lifestyle.

Table 3.4: Items in Likert-scale questionnaire that are related to H3.

Expected Endorsement Level	Item
Easy	5a. When using the prototype, it makes me feel like I am a part of a larger group of people.
Hard	5b. When using the prototype, it makes me feel like I am alone among many other people.
Easy	6a. When using the prototype, it feels like others can take part of my results and successes.
Hard	6b. When using the prototype, it feels like I am alone in seeing my results and successes.

Table 3.5: Likert-scale grading for the questionnaire, where a lower number indicates lower endorsement to the item, and a higher number indicates a higher endorsement.

1	2	3	4	5	6
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree

Table 3.6: Likert-scale grading for the questionnaire, in Swedish, where a lower number indicated lower endorsement to the item, and a higher number higher endorsement.

1	2	3	4	5	6
Instämmer inte alls	Instämmer inte	Instämmer delvis inte	Instämmer delvis	Instämmer	Instämmer helt

Table 3.7: Likert-scale grading and scoring for the questionnaire, where a-items result in higher score with higher endorsement, while b-items result in higher scores with lower endorsement.

Grading in user test	1	2	3	4	5	6
	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
Grading for scoring of a-items	-3	-2	-1	1	2	3
Grading for scoring of b-items	3	2	1	-1	-2	-3

## 4 Results

### 4.1 User Insight

#### 4.1.1 Brainstorming

The brainstorming session was carried out as described in Section 3. During the brainstorming, ideas were generated and then discussed and clarified. The ideas resulted in desired goals, considerations and functions, presented in Table 4.1, 4.2 and 4.3. The priority level of each function and consideration was determined after the brainstorming session without the expert group, based on the literature and aim of the thesis.

Table 4.1: Resulting desired goals from the brainstorming session.

Code	Goals
G1	Increase the motivation to be more physically active and/or eat healthier.
G2	Increase the compliance to taking recommended medication, such as blood pressure medication.
G3	Increase trust through personalized information.

Table 4.2: Resulting desired considerations from the brainstorming session.

Code	Considerations	Priority
C1	Consider uncertainty in models.	Low
C2	Be clear and careful in presented risks and calculations.	Low
C3	Consider patient/user interaction.	High
C4	Use gamification.	Low
C5	Extract relevant information from healthcare personnel working with the Health Dialogue.	Low
C6	Consider thought spirals.	Low



Table 4.3: Resulting desired functions from the brainstorming session.

Code	Desired Function	Priority
F1	Create “life stories” through animations.	Low
F2	Visualize future values with the help of mechanistic simulation models.	High
F3	Visualize prediction of risks due to specific physical activity or food intake, with the help of mechanistic simulation models in combination with a risk calculation model.	Low
F4	Simulate mechanistic meal models with different compositions of food (fats, carbohydrates, and proteins).	High
F5	Visualize movements of the user, such as walking, jumping, running and dancing.	High
F6	Visualize the specific muscles involved in a specific movement.	Low
F7	Visualize processes in the body due to certain activities, such as blood fat levels and glucose blood levels, due to for example a certain physical activity.	High
F8	Include an interactive “map” of the body	Low
F9	Use the Health Curve	High
F10	Provide opportunity to speak to a virtual future version of the user.	Low
F11	Provide opportunity to contact a health care personnel.	High
F12	Being able to make use of self monitoring devices (wearables).	High
F13	Enable creation and use of goals.	High

#### 4.1.2 Personas

Three personas were created based on Chapter 2: Gadget Gabriel, Caring Carin and Inactive Ingvar. The first persona is called Gadget Gabriel, for his passion in new small useful electronic devices. His persona is presented in more detail in Figure 4.1. The persona Caring Carin is a family woman who loves spending time with her children and grandchildren and always wants what is best for them, which is described in Figure 4.2. The third persona is Inactive Ingvar, who is a beloved work college, with a great interest in cars. He is described in more detail in Figure 4.3.

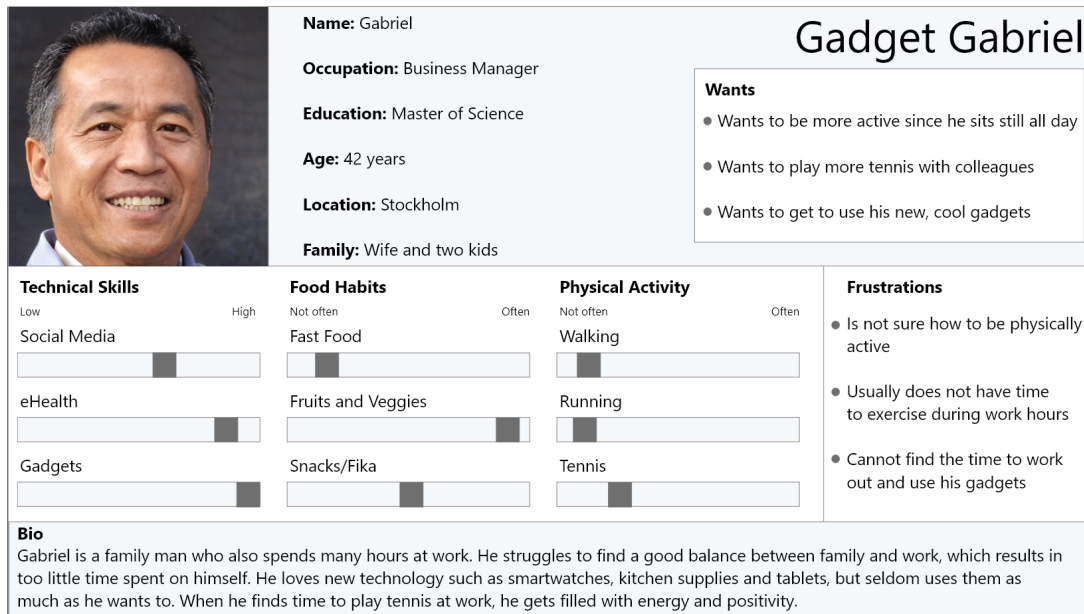


Figure 4.1: Persona 1 – Gabriel: A description of the persona Gabriel, his wants, habits, skills and frustrations, with an image generated by a GAN [7].

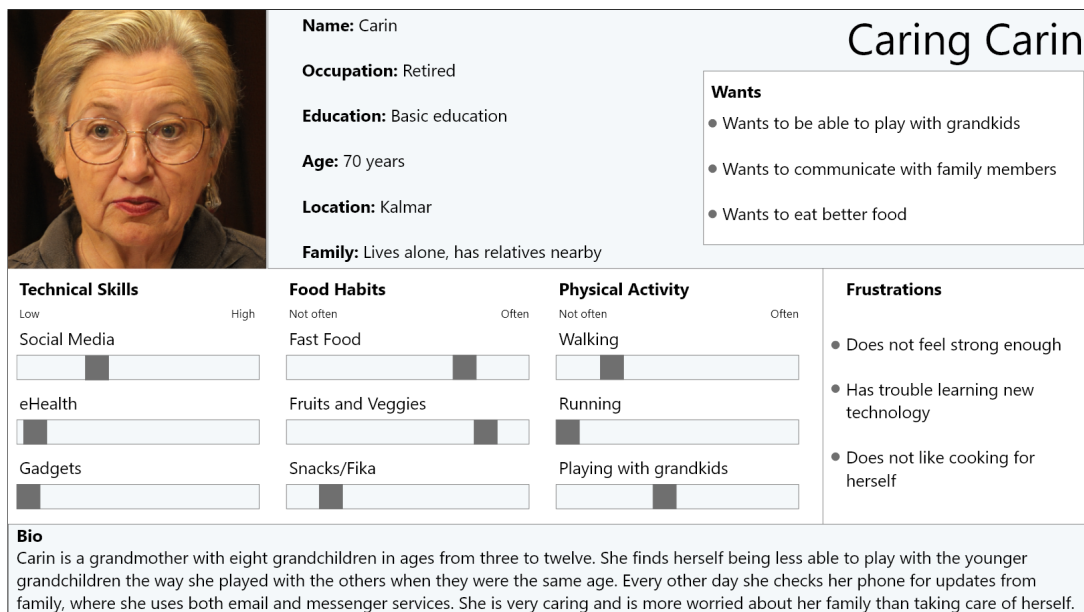


Figure 4.2: Persona 2 – Carin: A description of the persona Carin, her wants, habits, skills and frustrations, with an image generated by a GAN [7].

### 4.1.3 User Stories

These user stories represent the requirement functions for the intended system to be designed. Table 4.4, 4.5, and 4.6 present all user stories based on the needs for the three different personas, combined with the goals, considerations, and functions listed in Table 4.1, 4.2 and 4.3.

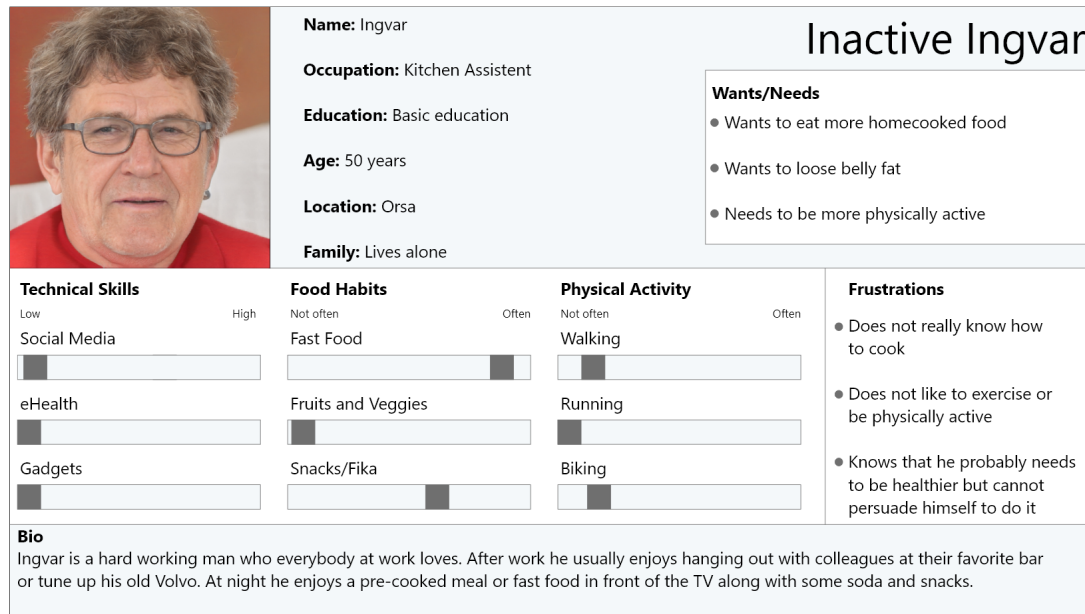


Figure 4.3: Persona 3 – Ingvar: A description of the persona Ingvar, his wants, habits, skills and frustrations, with an image generated by a GAN [7].

Table 4.4: User stories for the persona Gabriel with his needs and wants.

Code	User Story	Relates To
US1	Gabriel wants to see his predicted health values so that he can be reminded of the importance of taking time to exercise.	G1, F2, C3
US2	Gabriel wants to see correlations between his lifestyle habits, and health values and risks so that he can track his changes and improve his values and risks.	G2, F2, F3, F4, C1, C2, C3
US3	Gabriel wants to use his smartwatch to report daily activity to see progress on his goals.	G1, F1, C3
US4	Gabriel wants to report data such as food intake, blood pressure, weight and other, in order to personalize the twin as much as he can.	G3, C3

#### 4.1.4 Workshop

A workshop session was performed using some of the user stories created. The stories used were US4, US5, US6, US11, and US12. The result from the generated design ideas were used when creating the interface design.

## 4.2 Design

The design phase was carried out according to the method described in Section 3.2. A selection of figures from the resulting design from iteration 3 are presented in Figure 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, and 4.10 All figures from the final design prototype are found in Appendix B.

Table 4.5: User stories for the persona Carin with her needs and wants.

Code	User Story	Relates To
US5	Carin wants to visualize herself jumping and lifting to help motivate her to be able to do that again.	G1, F5, F10, C3
US6	Carin wants to see the different muscles involved in lifting and walking so she knows what muscles needs strengthening.	G1, F6, F8, C3
US7	Carin wants help to set up daily goals so she can reach her long term goal – to be able to continue playing with her grandchildren.	G1, F13, C3
US8	Carin wants to easily understand how to use a tool that will help her become more active so she does not give up on trying to learn how to use it.	G1, C3

Table 4.6: User stories for the persona Ingvar with his needs and wants.

Code	User Story	Relates To
US9	Ingvar needs to understand the effects of taking blood pressure medication so that his blood pressure decreases.	G2, F2, C1, C2, C3
US10	Ingvar needs some support to help change his lifestyle habits.	G1, F11, C3
US11	Ingvar needs to understand the risks of continuing with his food and activity habits so he does not suffer from disease or premature death.	G1, G3, F2, F3, F10, C1, C2, C3, C6
US12	Ingvar wants to see his Health Curve and updates of it, so that he easily can understand his health status.	G1, G3, F9, C3, C5



Figure 4.4: The top of the Health Curve page in the final prototype. Here, the user can see and overview of the health risks based on the Health Dialogue, or updated risks using uploaded data and digital twin technology. This function relates to US12.

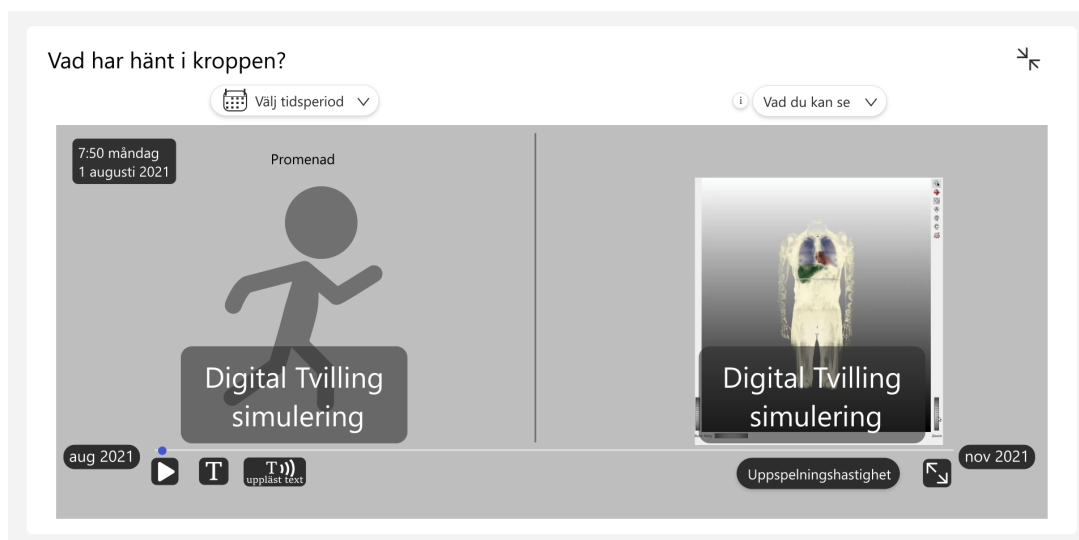


Figure 4.5: The digital twin used in the physical activity page in the final prototype. In this view, the user can potentially see all their recorded activities as a video with a correlating view of what happens inside the body. This relates to US6.

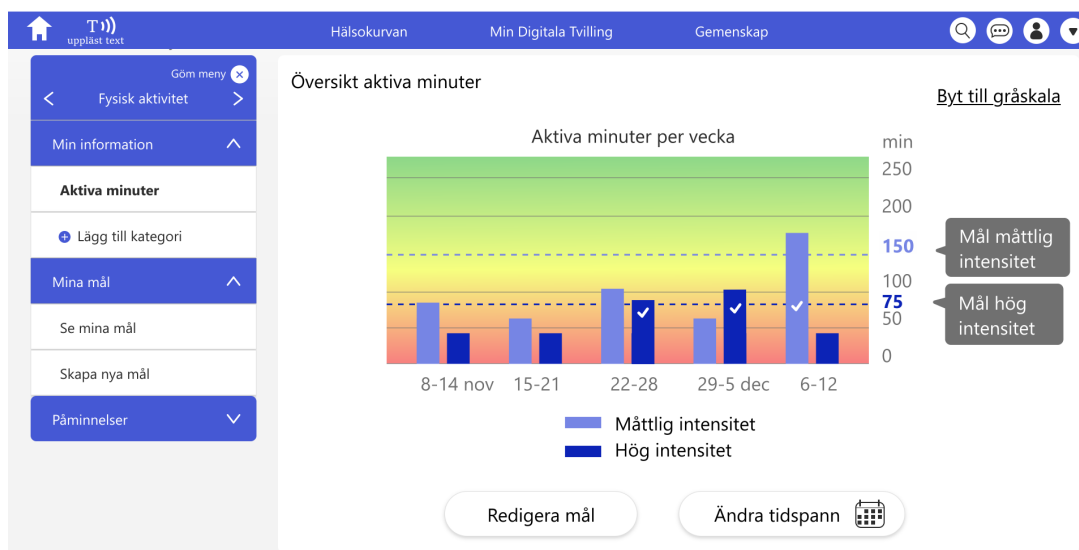


Figure 4.6: An overview of active minutes in the final prototype where the user can potentially edit a specific goal and potentially create new goals by using the left menu. This view relates to US7.



Figure 4.7: The top of the digital twin page in the final prototype. The user can from this view potentially choose to update the digital twin with new data, both from sensors and manually. It might also be possible to upload data from other health apps as well. This view relates to US3 and US4.

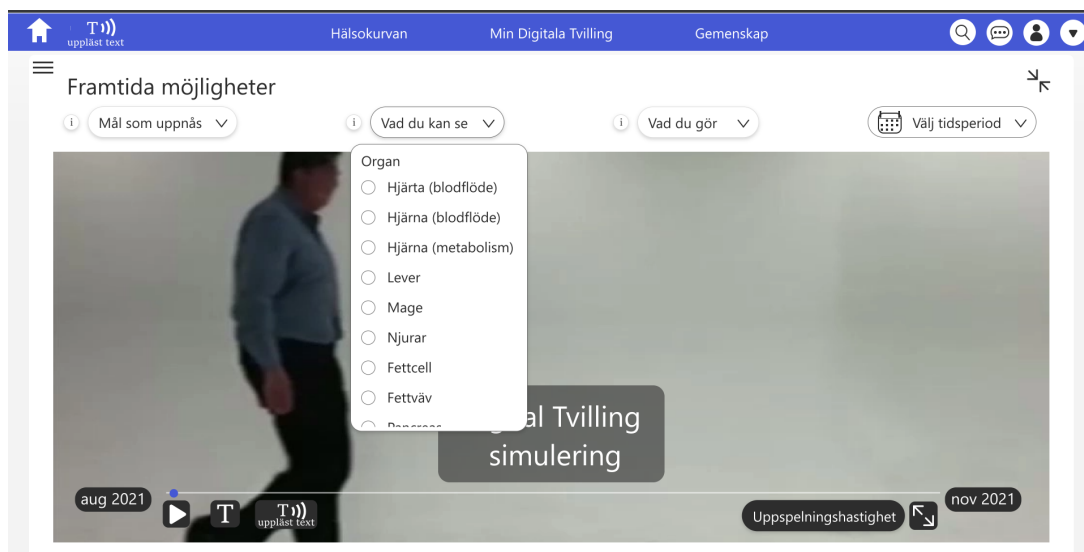


Figure 4.8: A digital twin view in the final prototype. A user can choose one or more goals that are expected to be achieved and choose to see which organs or health values to see future predictions of. Examples of future predictions further down in the list are Body Mass Index (BMI) and blood pressure. This relates to US1, US2 and US9. The user can also choose to see different movements of the digital twin when certain goals have been achieved or the effects of taking prescribed medication. This relates to US5 and US9.

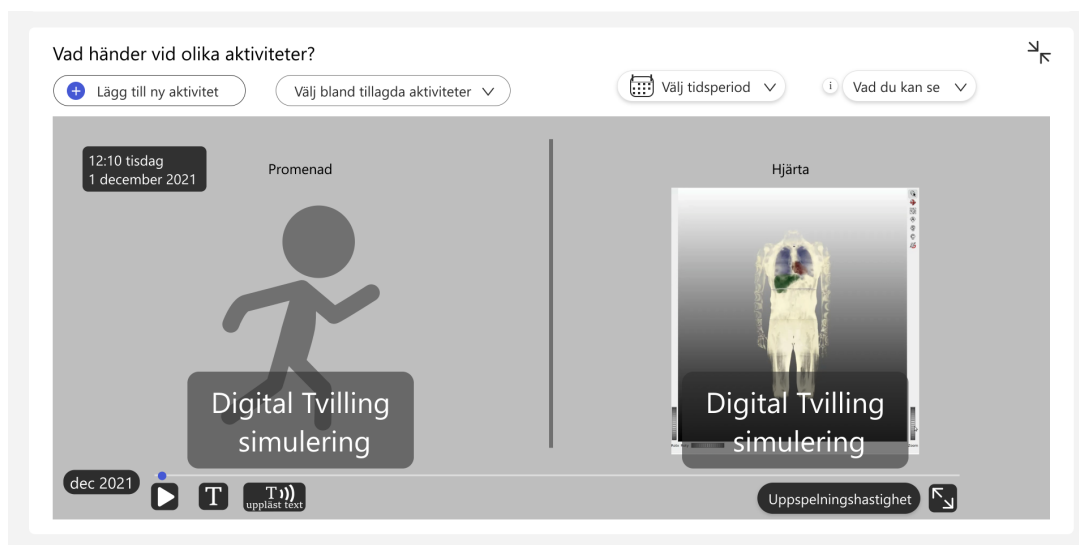


Figure 4.9: The bottom of the digital twin page in the final prototype. A user can potentially add new activities and create a schedule which would result in an overview of what happens in different parts of the body due to his lifestyle. This relates to US10 and US11. Also, a user can potentially see different muscles involved in certain movements, which relates to US6.

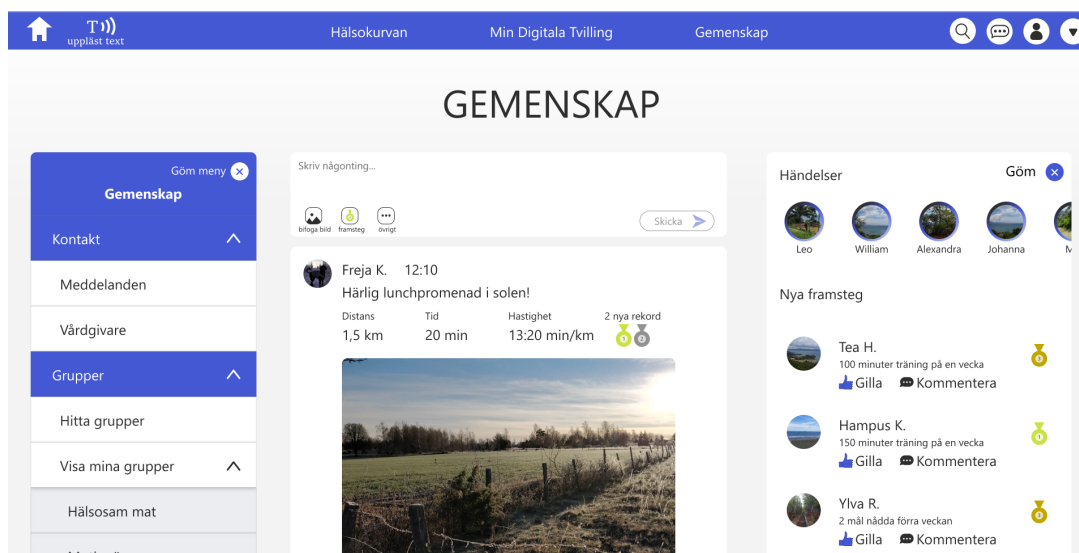


Figure 4.10: The top of the community page in the final prototype. In this view, a user can potentially communicate and form relationships with other people, and also potentially contact healthcare personnel. This view therefore relates to US10.

### 4.3 Evaluation

The evaluation was performed as described in Section 3.3. There were five participants in the user test, where all had a higher education. Two of the participants were biologically female, and three were biologically male. The participants' ages were in the range between 36 and 70; see Figure 4.11 for the specific age distribution. The percentage of participants who completed the tasks, presented in Section 3.3, are seen in Figure 4.12. Scores for each participant's answers in the Likert-scale questionnaire along with a total score for each hypothesis are presented in Table 4.7, which were based on the scoring Table 3.7 in Section 3.3.

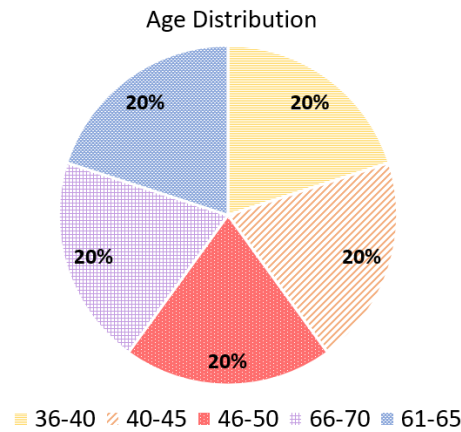


Figure 4.11: Age distribution of user test participants.

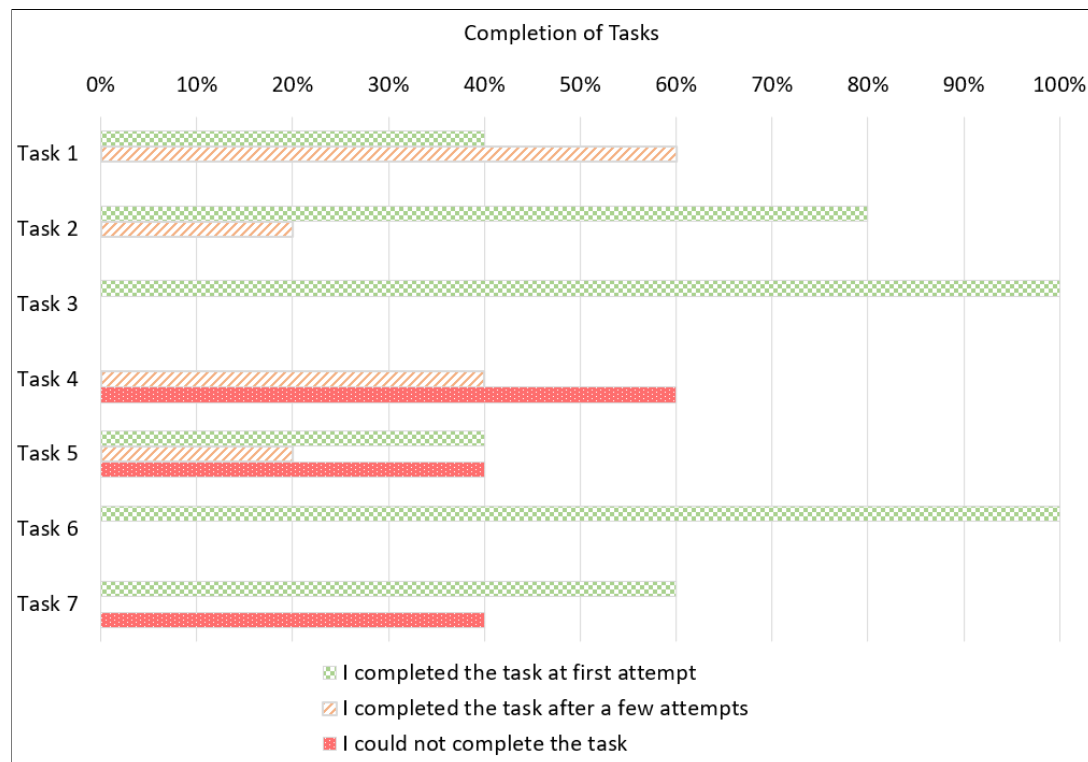


Figure 4.12: Results from user test tasks. The graph shows the percentage of participants who for each task could a) on the first attempt (green and squared), b) after a few attempts (yellow and striped) and c) could not (red and dotted) complete them.



Table 4.7: Scores for each participant performing the Likert-scale questionnaire. For each participant, each hypothesis is both scored separately and a total score is given. The average score for each hypothesis is also given.

Participant ID	H1 score	H2 score	H3 score	Total score
P1	0	7	5	12
P2	-12	-11	4	-19
P3	8	6	0	14
P4	9	7	5	21
P5	-1	-5	1	-6
<b>Average</b>	0.6	0.8	3	4.4

Some free text answers with feedback were also received from the participants. One participant did not understand how to use the design prototype and was unsure what could be added and changed when using it. Another participant stated that it was difficult to get an overview, since all functions did not work. The participant was unsure whether the task could not be performed due to the function not working, or if was caused by the participant being “clumsy”. Yet another participant found it hard to understand setting up goals and making changes in their lifestyle, since the prototype did not seem to provide that functionality. Therefore, that participant found it difficult to have an opinion regarding the questions involving goals and changes to the lifestyle. Additionally, a participant stated that “edit message” (*“redigera meddelande”*) was one of the tasks that could not be performed. There was also feedback saying it was “exciting” (*“Spännande!”*) and on its way to become something really good (*“...på god väg att bli något riktigt bra...”*).



## 5 Discussion

### 5.1 Results

#### 5.1.1 Design

There were several comments on functions of the design being unclear how to use or if they even could be used, which is to be expected. The design prototype cannot include all functions that a real web site potentially could. There are both limitations with the used software, Adobe XD, but also time limitations that cause the prototype to not be able to function as intended. However, it is not desirable to design a prototype for a new program in full detail and functionality. Instead, the prototype should provide enough detail and function so that the stakeholder and end users can get a general idea of the system and opportunity to suggest changes early in the process. Having a general overview of different functions in a suggested design creates a foundation for discussion and further work.

During the design phase, the limited time frame resulted in a constant balance between designing many functions and providing much detail. All expected goals, functions and considerations of the expert group were incorporated into the user stories for the three personas, but not all user stories were fulfilled completely. As the work was carried out in an agile way, not designing the user stories exactly as described is an encouraging approach if motivated.

Many functions, considerations and user stories was about presentation and calculation of risks. It was realized during the design phase that presenting detailed risk calculations of certain behaviors might be motivating to some, while it can be experienced as negative feedback or frightening to others. According to the literature, positive feedback increased adherence to physical activity, while negative feedback decreased the adherence [8]. It was therefore decided that new ways of presenting risks should not be designed; only the Health Curve should be used for presentation of risks in this prototype. The Health Curve is also a familiar presentation tool to the individuals who have performed the Health Dialogue, which might make it easier to use and understand how the system works.

Seeing as many of the functions overlap in the three different views including the digital twin, it would be beneficial to combine these three (Figure 4.5, 4.8 and 4.9). This would also enable US2 to be more fulfilled, however not completely since new risk presentations were not designed in the prototype. US8 is not realized in the views of the design, since it relates

more to a goal or expected outcome, rather than a specific function. The tools are deemed to be not as intuitive and easy to use as desired, and therefore, US8 is not fulfilled. All other user stories are included in the design on some level.

### 5.1.2 Evaluation

From Table 4.7, it shows that based on the participants' answers in the Likert-scale questionnaire, the average scores for each hypothesis are relatively low. As stated in Table 3.1, H1 is related to perceiving autonomy, H2 to perceiving competence and H3 to perceiving relatedness when using the prototype. H1 and H2 scored an average of 0.6 and 0.8, respectively, which is just slightly above zero. A negative score would indicate low endorsement for the items that were expecting high endorsement and/or high endorsement for the items expecting low. A negative score therefore indicates low perceived autonomy for H1, low perceived competence for H2 and low perceived relatedness for H3.

An average score just above zero for the H1 and H2 items indicates a neither high nor low perceived autonomy and competence, which is not strengthening the hypothesis. The users perceive relatedness to a slightly higher degree than autonomy and competence. The average score for H3 is 3, which is higher, but still not especially high compared to the maximum, which is 12. Therefore, H3 is not well supported. The conclusion from looking at the average scores is therefore that H3 is more supported than H1 and H2, but none of them are well supported. With the low number of participants, well supported hypotheses were not possible either way.

Since there are not many participants, looking at the individual scores might be of higher interest than the average score for each hypothesis. Two of the five participants had negative scores for H1, where one of them, P2, had -12, which is the minimum score possible for a hypothesis. This low score indicates that the participant did not perceive autonomy at all, which is a valuable result. From looking at the individual scores, it is also notable that there is a greater variance in the scores for H1 and H2, compared to H3. For H1, P2 scored -12, while P4 scored 9. Regarding H2, P2 scored -11 and P4 scored 7. This highlights the individual differences of the users, where all users can perceive the same design very differently. There also seems to be a correlation between H1 and H2, where the difference between the scores were less than 2 for three of the participants. From this, it can be concluded that the participants might not be able to feel autonomous if they do not feel competent, or the other way around.

H3 had a lower variance than H1 and H2, where all participants scored between 0 and 5 regarding H3. One reason for this could be due to only providing one design page in the prototype where the participants could form an opinion regarding the items of relatedness. Thereby, it might have been easier for the participants to experience the same feeling. Another reason for the low variance can be due to item 6a and 6b. These items might be poorly formulated and may have resulted in some support of them, although the items do not necessarily measure relatedness of the participants. Another noteworthy result is that the scores were more neutral for H3 compared to H1 and H2, where the scores were more extreme. A reason for the relatively neutral scores could be that the participants were not able to form opinions regarding relatedness. The participants cannot form actual relationships and connections through the tested prototype, which could cause more neutral opinions.

Although there were not many participants, the results still show that some people got neutral and negative scores. Therefore, these people could not perceive autonomy, competence and relatedness, and further work is needed for the design to motivate individuals toward healthy lifestyle habits. Examples of further work to support the hypotheses are to change the design, the tasks, and the items. However, most likely, a complete functional system would have to be implemented to fully contribute to motivation.

Figure 4.12 shows the percentage of participants who completed each task. All participants managed to complete the first three tasks, which was expected, since these tasks only needed scrolling or one click to be completed. No participant managed to complete the fourth task on the first attempt, which is also to be expected since the play-button to play the video did not work in the prototype. Instead, the user had to click on the image for the video to start playing, which is not as intuitive as pressing a play button. Therefore, some needed a few attempts, while others did not manage to complete the task at all. The task of playing a video was mainly created to give the user an opportunity to see how the digital twin videos could provide insight about the body. The goal with this insight was that the participants should feel more competent when given a view of the body in relation to some activity. However, due to more than half not being able to complete it and the poor support for H2, it seems that this function needs to be clarified and presented in a better way.

There was a comment by a participant relevant to discuss. The participant stated that they could not fulfill the task “edit message” (“*redigera meddelande*”). This probably refers to task 7, where the user was prompted to react to a message (“*reagera på ett inlägg*”). This is noteworthy since it highlights that the users cannot be expected to read everything correctly. In this case, the words edit and react are quite similar in Swedish (*redigera* and *reagera*), which resulted in confusion for the user. Another interesting detail is that each task had an image with the view expected when the task was finished. From this, the user could have been helped to understand the task better and know what was expected. This indicates that several users might need extra support when starting to use the final system, and that images and texts would most likely not be sufficient for some users to use the system.

The literature stated that a 6-point scale was the most common, and that a “neutral” option should be avoided since the participants should be able to form an opinion. However, in this thesis, a neutral option might have been beneficial, which could be achieved by using a 5-point scale. Now, when the free text answers indicated that some participants could not form opinions regarding some of the items, they felt forced to answer as if they had an opinion. It would have been interesting in this case to see how many participants did not have an opinion regarding different items, since that would be helpful when continuing the work of the design, tasks and/or items.

An attempt to avoiding test user bias was made by not letting friends or family members participate in the user test. Instead, the Department of Biomedical Engineering at Linköping University was asked to participate themselves or forward the user test to people they knew in the targeted age group (40-80 years). Although the bias of relatives was removed, using only this group as a survey group most likely caused sampling error bias regarding higher education, based on the literature of Sataloff and Vontela [18]. The participant of the survey group all have a higher education, which could be explained by the user test only being sent to people with higher education.

The participants’ education level might also be caused by the user test being conducted online, with no possibility for assistance. Therefore, the likelihood of people with primary school education conducting the user test decreases, based on the literature. As stated in Section 2.1, individuals with higher education are more likely to use an eHealth service than individuals with primary school education (81 % of internet users compared to 56 %) [26]. This results in an increased expectation of participants with higher education. Although no participant with primary school education is represented in the user test, an assumption of this group can be made based on the literature. Kristenson state that people with lower level of education often have more unfavorable habits, which could be caused by amotivation or external motivation, described by Ryan and Deci [16]. Hence, the assumption is that since the hypotheses are not well supported for users with higher education, the hypotheses most likely will not be supported for users with primary school education either.

The ages of the participants vary in the span 36-70 years, and there are both men and women who participated. The only group not present is 71-80 years and 51-60 years. The study was too small to make assumptions based on age or gender, but it was noted that neither gender nor age did necessarily correlate to a higher or lower endorsement to the items about the interface design prototype. Furthermore, no correlation between the completion of tasks was found.

The diversity of the participants is unknown, since this was not asked for in the user test. Based on the literature, people born outside Scandinavia have used an eHealth service just as much as the average internet user. Therefore, it was deemed unnecessary to include a question regarding birth country in the user test.

As described in Section 2.8, Sataloff and Vontela state that a nonresponse bias occurs when there is a large difference between the respondents and non-respondents [18]. This is true in this evaluation, since there were many in the surveyed group not participating, while only five people participated. As a result, there are potentially many opinions not represented in the evaluation of the thesis. However, the participation of the five individuals still provides useful insights that will be described in more detail in the next section.

## 5.2 Method

There are several limitations when creating a prototype, where it is difficult to imitate a final system. Creating a prototype instead of an actual system might have been a reason for the weak support for the hypotheses. Autonomy, competence and relatedness are aspects of intrinsic motivation, which might not be possible to satisfy with only a prototype but might instead need a fully functioning system. These concepts will be discussed further in relation to the chosen method.

Regarding autonomy, in Section 2.4 it is stated that a user can perceive autonomy by being able to choose its own path from different alternatives, instead of having a linear path of tasks according to Bodestad and Brohede [2]. Kilpatrick, Hebert, and Jacobsen also stated something similar regarding adherence to physical activity, mentioned in Section 2.3, where providing several activities to choose from develops both participant satisfaction and autonomy [8]. Furthermore, Kilpatrick, Hebert, and Jacobsen stated that a brief description of why an activity has been selected could also develop autonomy [8]. This is difficult to achieve in a prototype, since all options cannot be designed for, and the participants instead need to be guided through a linear path that the design allows. Therefore, the user test itself might decrease the sense of autonomy due to feeling pressured to only follow instructions without understanding why. It might be difficult for the participants to separate the feelings gained from performing the test, compared to feelings that could be gained from using the system prototype, which could skew the results.

Much related to perceiving competence is connected to setting up goals, according to the literature. Due to this function not being designed for, it was difficult for the participants to have opinions regarding those questions. As stated by Bodestad and Brohede, shortening the path to the goal and shortening the time span of the goal are two ways to design for emotion [2]. These two ways increase the likelihood of fulfilling tasks of the program due to increased motivational drive and desire to continue with tasks and eventually complete more difficult tasks. They also stated that starting small, achieving early success, and increasing the difficulty as the ability increases can be useful tools to help succeed with tasks, especially when an individual is amotivated. These factors are said to help with desire to continue as the individual feels competent and able to perform the planned tasks. Therefore, since setting up goals is not possible in the prototype, the likelihood of participants feeling competent decreases. Also, it might not be possible for the participants to feel competent until they can use the product for real.

Another aspect related to competence is the power of positive feedback, mentioned by Kilpatrick, Hebert, and Jacobsen [8]. It is stated that positive feedback about a participant's performance regarding physical activity helps develop self-confidence and competence, while negative feedback can result in the opposite [8]. An attempt to implement this positive feedback is done through task 5, where an encouraging text says, "Good job!" and images help visualize the progress. 40 % of the participants could not complete this task and therefore not read this text. Also, since the participants have not actually performed the physical activity that the positive feedback refers to, it might be another reason for most of the participants not perceiving competence to a higher extent.

Relatedness can also be difficult to perceive by the participants of the user test, since the design does not contain personal relationships; the design only provides the opportunity to view potentials of a final system. By encouraging social connections, social relationships can be developed in a physical activity context, which would help develop relatedness according to Kilpatrick, Hebert, and Jacobsen [8]. Encouraging social connections in other contexts might have the same effect, which is why the idea of social groups are introduced in the prototype. Since the score for H3 had lower variance than the other two hypotheses, and the scores were positive, it seems that the participants had noticed the potential of creating relations. Although, since their scores were between 0 and 5, it seems they cannot fully feel related without developing the relationships themselves.

The method does not have high replicability or reliability regarding the design phase since the design phase can differ drastically each time the method is repeated. The evaluation phase has higher replicability, since it can be used to evaluate another design. However, the evaluation phase does not have high reliability, since similar results would only be obtained provided the same design prototype is used. If there is another design created the results would most likely differ from the ones obtained in this thesis. Although, there is a possibility that the results would be similar, since, as previously discussed, the concepts autonomy, competence and relatedness might not be possible to achieve in a design prototype. There is no need for the design phase to have high replicability or reliability, but replicability in the evaluation phase might be desirable. If the work regarding the design is continued, the evaluation method could be used to evaluate the next design, which would hopefully provide results that support the hypotheses more.

The validity of the results can be questioned since the user test might not measure feelings gained by using the the prototype, but instead feelings gained by performing the test itself, as mentioned previously in Section 5.2. The tasks were attempted to be written in a way that only guides the user through the interface to get and understanding of the basic functions. Instead, the user might feel limited, which would decrease autonomy. Therefore, due to the low validity, the credibility of the results is also low. As a result, if the evaluation method is used, it is recommended to rework the task descriptions and items as an attempt to increase validity and credibility for their work.

The sources chosen for the thesis are mainly peer-reviewed articles or books, and some websites. The websites are mainly used for definitions and statistics where the source of the data is provided by the organization or authority of the website, such as WHO, Socialstyrelsen and Socialdepartementet. Other websites used are only references to programs or tools that have been used, such as Adobe XD and Google Forms. An attempt to use more recent sources was made, especially since the field of eHealth and medical technology is rapidly evolving. Some theory, such as theory about self-determination [16], [8], is nevertheless from 2000 and 2002, which is considered relatively old. Clearly, new insights on different types of motivation can have been found since then. As a complement to the older theory about motivation, theory about psychological design [2] was used. These three sources do not contradict each other, which indicates that the self-determination theory is still valid and can be combined with newer theory to understand motivation towards different behaviors.

### 5.3 The Work in a Wider Context

When new systems are introduced to the world, the possible consequences of its existence must always be considered. Ethical and societal aspects will be discussed in relation to the resulting design prototype of this thesis.

Some of the considerations performed in the design are regarding accessibility for people with varying ability. In the header at the top of each page, there is a symbol including the letter "T". The idea is that by pressing this button in the final system, the text on the page will be read out loud. Being able to hear the text, instead of reading it, would make the system more usable to a larger population of the society. Another attempt to consider varying abilities regarding sight was by providing the option to change colorful pages to an adapted greyscale page. No greyscale page was not implemented in the design, but intended for a final system. Being able to listen to text and adapting colored pages relate to the literature where Story presents her principals of universal design [25].

Story created seven principles of universal design, where the first two principles relate to including people with varying ability and providing options for method of use [25]. These two principles are considered in the design of this thesis through the read text option and greyscale option. However, there are many other varying abilities that are not accommodated for, and there are more considerations that can be done to achieve better usability for more people. For example, people without a computer or smartphone would be excluded from usage, and people with varying mental ability might find it difficult to use the system. In conclusion, even though an attempt was made to include more people to be able to use the system, some are still excluded from taking part of it.

As mentioned by the research group and discussed in Section 5.1, the presentation of risks needs careful consideration. Calculations always have a level of uncertainty, and trusting the risk percentage of certain outcomes can have impacts on the individual using the system. For example, how will a person react to an obtained risk regarding having a stroke? A high risk for stroke might cause the person to live in fear, caused by the individually calculated risk based on the combination of individual data and mathematical models. The person might develop anxiety and get poorer mental health instead of being motivated to perform changes that would lower the risk for stroke. Is it ethical to provide such detailed risk calculation without any support of a healthcare professional, if the risks are really high? On the other hand, if the risks are high, and the person does not respond to general information, is it ethical to not provide the individualized information that could help the person prevent a stroke? There are many possible outcomes of presenting risks to individuals, which is why it needs further studying to ensure the best possible outcome for most amount of people.

The community page in the design prototype could lead to people encountering negative comments or messages from other people, since this is not ethical to regulate. People would be free to express themselves, but when the behavior is detrimental to others, there should be regulations of how to handle this. A method that might prevent most people from such bad behavior towards others could be to use e-identification to log in to the system. This method allows appropriate legal measures to be taken with the help of the personal information connected to the account. Although the system stores personal information, a user should be able to use a username to remain anonymous towards others.

The overall goal with the work done in this thesis is to have a positive societal impact. In future systems, where this work can be used, many people can be helped regarding having healthier lifestyles, resulting in fewer people developing diseases or suffering from premature death. If enough people can be affected by a system similar to the one designed in this thesis, it would have a great positive impact on society as a whole.



## 6 Conclusions

**Can an interface design using digital twin technology in combination with the Health Curve be designed to fulfill autonomy, competence, and relatedness of the user, and thereby contribute to motivation towards a healthier lifestyle?**

From the literature, it seems that the design of an interface can affect the level of autonomy, competence and relatedness. These concepts can for example be affected by letting the user choose their own path, by giving positive feedback and by encouraging social relationships. The evaluation of the interface design prototype indicated that some participants supported the hypotheses to some extent, while others did not support them. There was a higher variance in the support for the hypotheses regarding autonomy and competence, compared to relatedness. The support for the hypothesis regarding relatedness was also more neutral compared to the other hypotheses. Overall, there is not enough support for the hypotheses, and therefore, the design prototype was assessed to not be able to fulfill the three concepts of motivation.

It was concluded that it would be difficult to perceive autonomy, competence and relatedness using only a prototype such as the one created in this thesis. These motivational concepts would be difficult to fulfill since the idea of the system revolves around individualization and options, which is not possible in an interface prototype like the one designed. Due to low support of the hypotheses proposed, the interface design was assessed to not be able to contribute to motivation of healthy lifestyles of the users. However, the design and evaluation method might help in further development of a system that can contribute to motivation of healthy habits in the future.

### **Future Work**

This thesis resulted in a design prototype, which has created a foundation for future development of an application of the digital twin in a clinical setting. Student projects can continue the work of this thesis and develop an actual web or mobile application connected to a back-end containing mathematical models, developed by the research group. This application could then potentially present individualized predictions of different functions of the body, which hopefully could help motivate individuals towards a healthy lifestyle.



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The evaluation method can be improved to obtain better results for future evaluations of interface designs. First, the tasks could be revised and adapted to the new interface. Also, the items in the Likert-scale questionnaire could be rephrased, and the outcome space could possibly benefit from having a 5-point scale instead of a 6-point scale.

There is a great potential for creating detailed risk calculations using the digital twin technology developed by the research group. Since the technology is so new, further studies would need to be conducted to understand the effects of the presentations of risks. It would therefore be of great interest and relevance to investigate how the risk calculations can be presented in a way to increase motivation.

For future development of the design, some current functions could benefit from being changed or removed and some new functions could be added. Functions that should be changed are the ones related to the digital twin, where the interface can be simplified and functions can be combined in fewer views. Another function to change is how activities are added to create a schedule (Figure 4.9). Instead, it would be easier and give a better overview if activities could be added to a weekly calendar, which could both show the activities planned, and the ones that were performed. A view that might be unnecessary if adding a weekly calendar is the calendar overview related to physical activity (shown in Figure A.4). Finally, if there are good ways to present risk calculations, this should be added to the system to further prevent harmful health habits, and instead encourage a lifestyle for a better health.



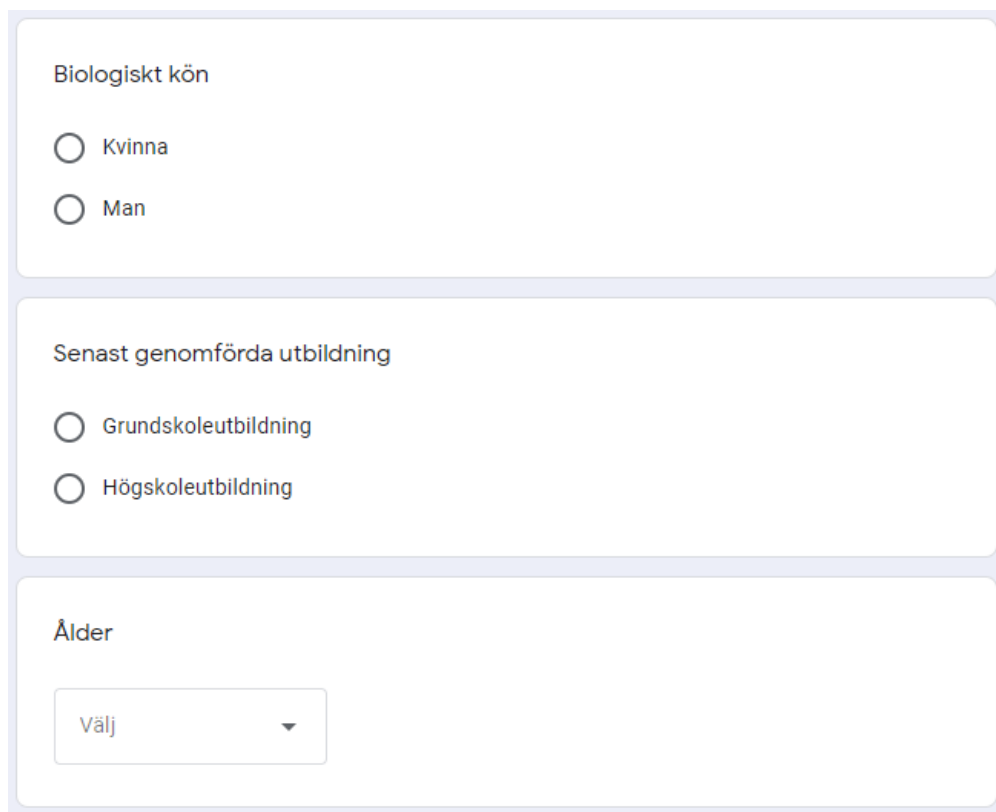
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# A User Test



The form is titled 'User test background information' and is divided into three sections. The first section, 'Biologiskt kön', has two radio button options: 'Kvinna' and 'Man'. The second section, 'Senast genomförda utbildning', has two radio button options: 'Grundskoleutbildning' and 'Högskoleutbildning'. The third section, 'Ålder', features a dropdown menu with the text 'Välj' and a downward arrow.

Biologiskt kön

☐ Kvinna

☐ Man

Senast genomförda utbildning

☐ Grundskoleutbildning

☐ Högskoleutbildning

Ålder

Välj ▼

Figure A.1: User test background information.


### Uppgift 1

Undersök vilka alternativ som finns på start-sidan

Detta stämmer bäst in på uppgift 1:

- ☐ Jag genomförde uppgiften på första försöket
- ☐ Jag genomförde uppgiften efter några försök
- ☐ Jag kunde inte genomföra uppgiften

Avklarad uppgift 1



The screenshot shows the app's home screen. At the top is a blue navigation bar with a home icon, a 'Toll' button, and three menu items: 'Hälsokurvan', 'Min Digitala Tvilling', and 'Gemenskap'. Below the navigation bar is a horizontal progress bar with four segments: green (>2000), yellow (1000-2000), orange (500-999), and red (<500). A hand icon is pointing at the orange segment. Below the progress bar is a blue section with a grid-patterned person icon and the text 'MIN DIGITALA TVILLING >'. At the bottom is a light blue section with the text 'GEMENSKAP >'. There are three speech bubbles: one on the left saying 'Bra jobbat med dina mål, ...', one in the middle saying 'Fortsätt kämpa, du är grymt /Elin', and one on the right saying 'Vilka framsteg du har gjort, jag är imponerad! /Will'.

Figure A.2: User test task 1.

## Uppgift 2

Titta på Hälsokurvan

Detta stämmer bäst in på uppgift 2:

- ☐ Jag genomförde uppgiften på första försöket
- ☐ Jag genomförde uppgiften efter några försök
- ☐ Jag kunde inte genomföra uppgiften

## Avklarad uppgift 2



Figure A.3: User test task 2.

### Uppgift 3

Se mer information om fysisk aktivitet

Detta stämmer bäst in på uppgift 3:

- ☐ Jag genomförde uppgiften på första försöket
- ☐ Jag genomförde uppgiften efter några försök
- ☐ Jag kunde inte genomföra uppgiften

### Avklarad uppgift 3



Figure A.4: User test task 3.



#### Uppgift 4

Välj att se vad som hänt i hjärtat vid en promenad (play-knappen fungerar ej i denna prototyp)

Detta stämmer bäst in på uppgift 4:

- ☐ Jag genomförde uppgiften på första försöket
- ☐ Jag genomförde uppgiften efter några försök
- ☐ Jag kunde inte genomföra uppgiften

#### Avklarad uppgift 4



Figure A.5: User test task 4.

### Uppgift 5

Se mer information om de minuter du har varit fysiskt aktiv

Detta stämmer bäst in på uppgift 5:

- ☐ Jag genomförde uppgiften på första försöket
- ☐ Jag genomförde uppgiften efter några försök
- ☐ Jag kunde inte genomföra uppgiften

Avklarad uppgift 5

Figure A.6: User test task 5.

## Uppgift 6

Se vad vänner har skrivit i flödet

Detta stämmer bäst in på uppgift 6:

- ☐ Jag genomförde uppgiften på första försöket
- ☐ Jag genomförde uppgiften efter några försök
- ☐ Jag kunde inte genomföra uppgiften

## Avklarad uppgift 6

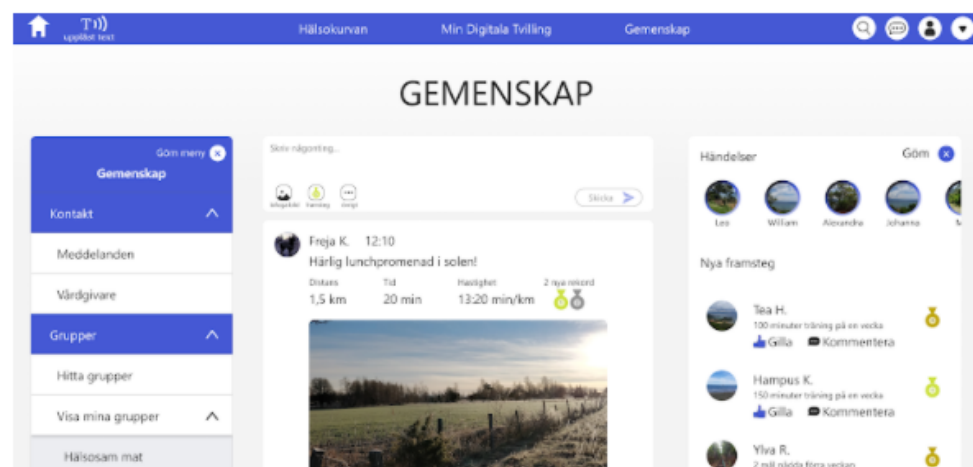


Figure A.7: User test task 6.

### Uppgift 7

Se vilka alternativ som finns när du försöker reagera på ett inlägg

Detta stämmer bäst in på uppgift 7:

- ☐ Jag genomförde uppgiften på första försöket
- ☐ Jag genomförde uppgiften efter några försök
- ☐ Jag kunde inte genomföra uppgiften

### Avklarad uppgift 7

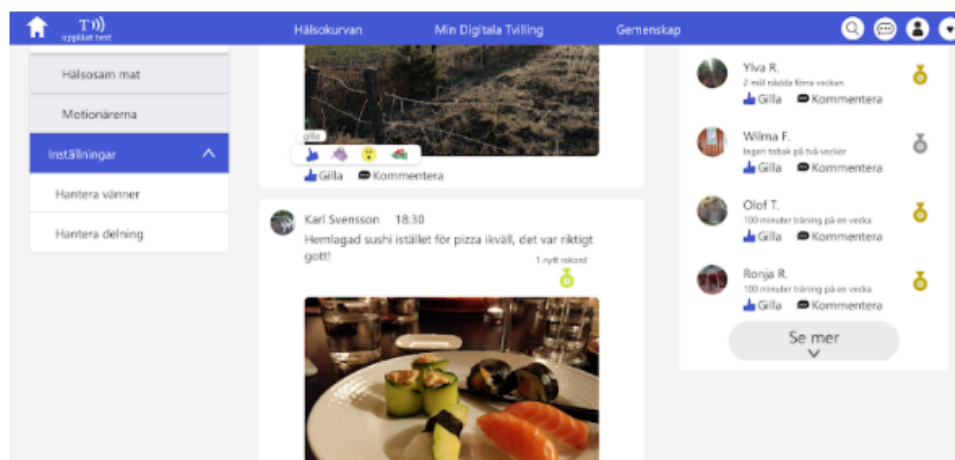


Figure A.8: User test task 7.

När jag använder prototypen känns det som att jag kan få hjälp av verktygen i den för att förändra något i min livsstil.

1

2

3

4

5

6

Instämmer inte alls

☐

☐

☐

☐

☐

☐

Instämmer helt

När jag använder prototypen känns det som att jag är ensam om att kunna se mina resultat och framgångar.

1

2

3

4

5

6

Instämmer inte alls

☐

☐

☐

☐

☐

☐

Instämmer helt

När jag använder prototypen känns det som att någon annan bestämmer vilken förändring i min livsstil som jag ska arbeta med.

1

2

3

4

5

6

Instämmer inte alls

☐

☐

☐

☐

☐

☐

Instämmer helt

När jag använder prototypen får det mig att känna att jag kan vara en del av en större grupp människor.

1

2

3

4

5

6

Instämmer inte alls

☐

☐

☐

☐

☐

☐

Instämmer helt

Figure A.9: User test Likert-scale questionnaire.

När jag använder prototypen förstår jag hur jag ska använda de presenterade verktygen.

1 2 3 4 5 6

Instämmer inte alls ☐ ☐ ☐ ☐ ☐ ☐ Instämmer helt

När jag använder prototypen har jag svårt att tänka mig att verktygen som presenteras kan hjälpa mig att förändra något i min livsstil.

1 2 3 4 5 6

Instämmer inte alls ☐ ☐ ☐ ☐ ☐ ☐ Instämmer helt

När jag använder prototypen känns det som att någon annan bestämmer över hur jag ska göra för att förändra något i min livsstil.

1 2 3 4 5 6

Instämmer inte alls ☐ ☐ ☐ ☐ ☐ ☐ Instämmer helt

När jag använder prototypen känns det som att jag får bestämma över vilken förändring i min livsstil som jag ska arbeta med.

1 2 3 4 5 6

Instämmer inte alls ☐ ☐ ☐ ☐ ☐ ☐ Instämmer helt

Figure A.10: User test Likert-scale questionnaire.

När jag använder prototypen får det mig att känna att jag är ensam bland många andra människor.

1 2 3 4 5 6

Instämmer inte alls ☐ ☐ ☐ ☐ ☐ ☐ Instämmer helt

När jag använder prototypen har jag svårt att förstå hur jag ska använda de presenterade verktygen.

1 2 3 4 5 6

Instämmer inte alls ☐ ☐ ☐ ☐ ☐ ☐ Instämmer helt

När jag använder prototypen känns det som att andra kan ta del av mina resultat och framgångar.

1 2 3 4 5 6

Instämmer inte alls ☐ ☐ ☐ ☐ ☐ ☐ Instämmer helt

När jag använder prototypen känns det som att jag får bestämma över hur jag ska göra för att förändra något i min livsstil.

1 2 3 4 5 6

Instämmer inte alls ☐ ☐ ☐ ☐ ☐ ☐ Instämmer helt

Figure A.11: User test Likert-scale questionnaire.

---



Övriga kommentarer

Ditt svar

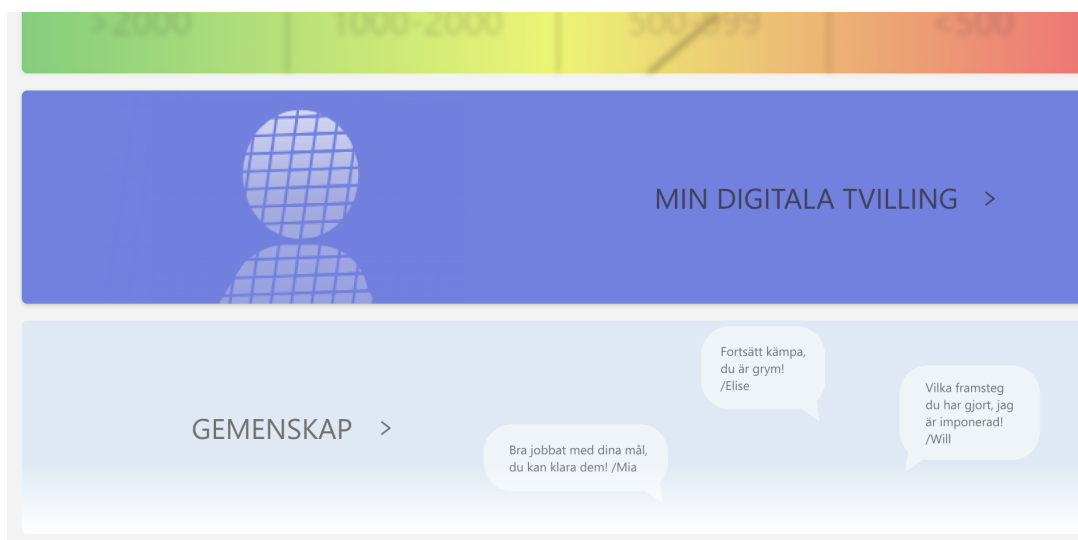
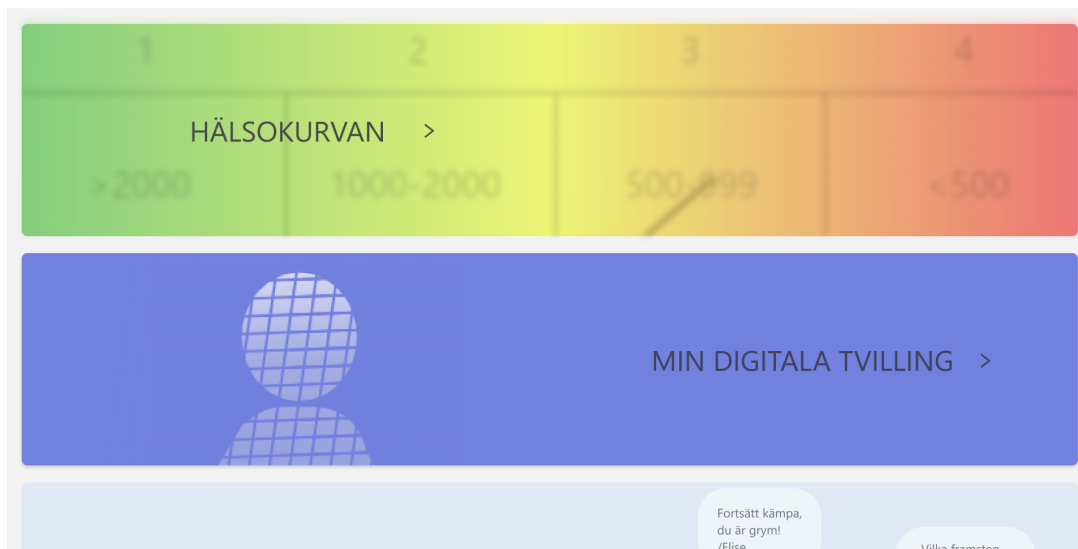
The image shows a user feedback form. It consists of a light blue rectangular container. Inside, there is a white rounded rectangle. At the top of this white area is the text 'Övriga kommentarer'. Below it is a horizontal line, and below that is the text 'Ditt svar'.

Figure A.12: User test optional feedback.



# B Final Design Prototype





Hälsokurvan
Min Digitala Tvilling
Gemenskap

## HÄLSOKURVAN

Din hälsokurva
Byt till gråskala

Välj tidsperiod ▼

OBS: Under tidsperioder är kurvan uppskattad beroende på den information du har lämnat in, och blir mer lik verkligheten desto noggrannare du har fyllt i.

		Låg risk <span style="float: right;">Hög risk</span>			
		1	2	3	4
▲ Fysisk aktivitet	> kcal /vecka	>2000	1000-2000	500-999	<500
▲ Mat	> Kost-poäng	3-5	6-9	9-11	

## HÄLSOKURVAN

### Din hälsokurva

Byt till gråskala

- ▲ förbättring jämfört med förra mätningen
- ▼ försämring jämfört med förra mätningen
- ingen skillnad jämfört med förra mätningen
- inget nytt resultat möjligt

beroende på den  
kligheten desto

Låg risk				Hög risk			
1	2	3	4	1	2	3	4
>2000	1000-2000	500-999	<500				
3-5	6-9	9-11					

▲ Fysisk aktivitet

>

kcal /vecka

▲ Mat

>

Kost-poäng

## HÄLSOKURVAN

### Din hälsokurva

Byt till gråskala

Välj tidsperiod

- ☐ Från hälsosamtal
- ☐ Annan tidsperiod
- ☒ Välj tid

kurvan uppskattad beroende på den  
in, och blir mer lik verkligheten desto

Låg risk				Hög risk			
1	2	3	4	1	2	3	4
>2000	1000-2000	500-999	<500				
3-5	6-9	9-11					

▲ Fysisk aktivitet

>

kcal /vecka

▲ Mat

>

Kost-poäng

## HÄLSOKURVAN

▼ Alkohol

>

Glas /vecka

▼ Tobak

>

Cig /dag

• Livssituation

>

• Psykisk ohälsa

>

• Ärftlighet, diabetes

>

• Ärftlighet, Hjärt-Kärl-sj

>

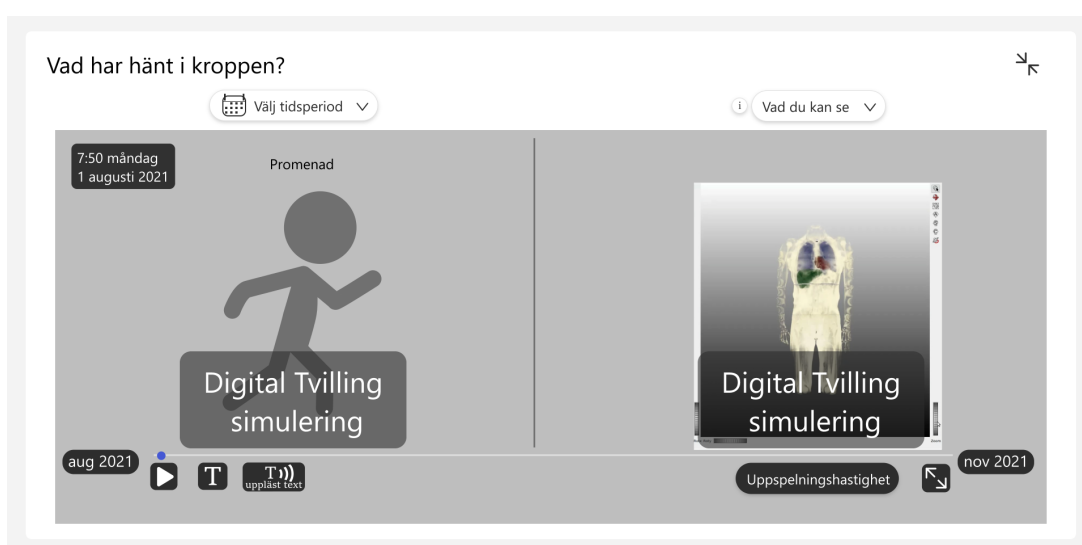
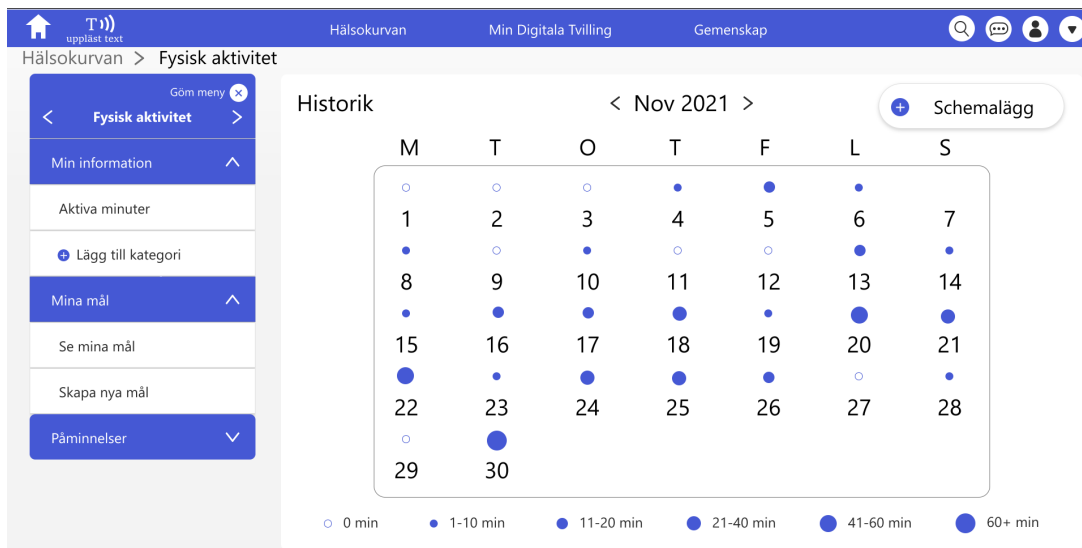
Far (ålder)  
Mor (ålder)

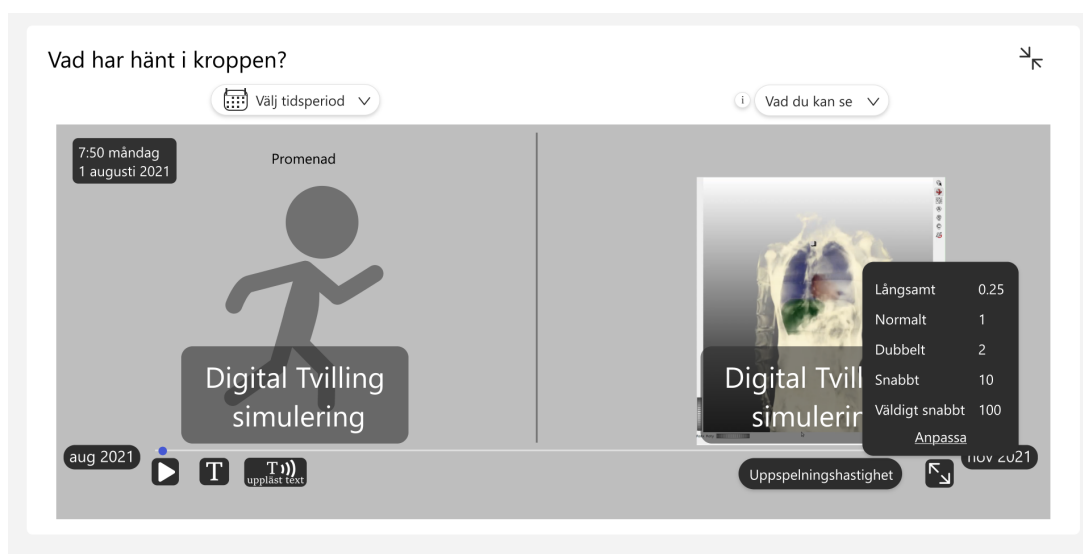
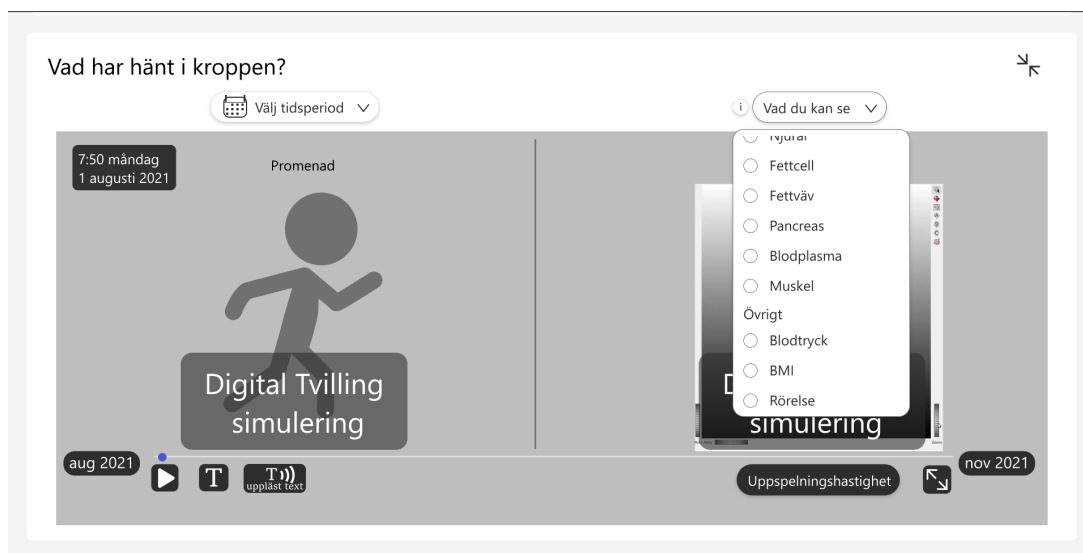
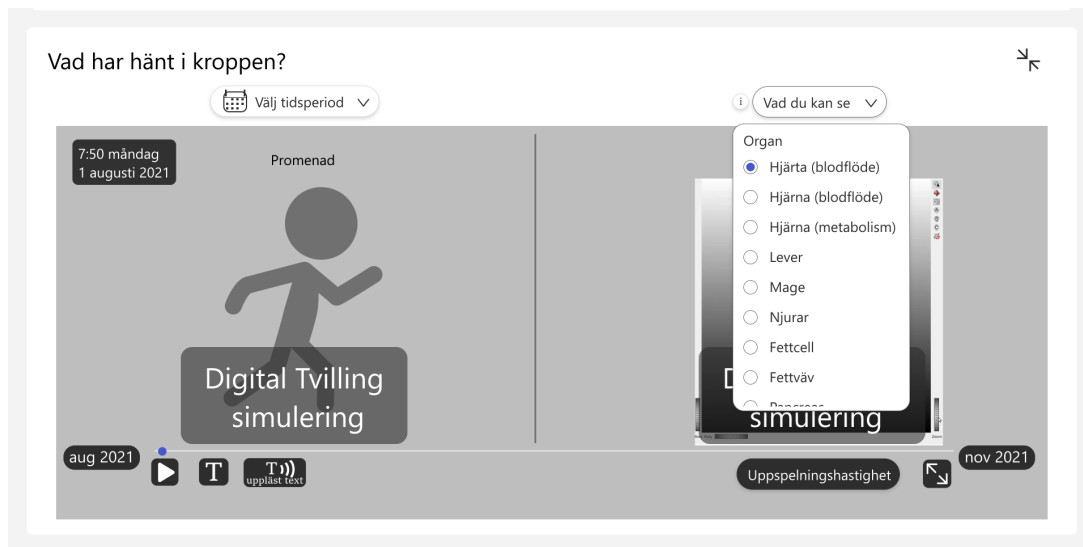
Låg risk				Hög risk			
1	2	3	4	1	2	3	4
♂ ≤6 ♀ ≤4	7-13 5-8	14-18 9-12	>18 >12				
0/ex	(snus)	1-9	9				
<2	2-3	4-5					
1	3-4	5-7					
0	1	>2					
♂ ≥70 ♀ ≥75	55-69 60-74	45-54 50-59	<45 <50				

▲ BMI	>	kg/m <sup>2</sup>	♂ <27 ♀ <29	27-35,9 29-35,9	≥37 ≥39	
– Midja-Stuss-kvot	>		♂ <0,90 ♀ <0,78	0,90-0,94 0,78-0,82	0,94-0,99 0,83-0,87	≥1,00 ≥0,88
– Blodtryck	>	mm Hg	♂ <140 ♀ <90	140-169 90-104	170-199 105-114	≥200 ≥115
– Kolesterol	>	mmol/l	♂ ≤5,00 ♀ ≤5,00	5,00-6,49 5,00-7,00	6,50-9,00 7,10-9,00	>9,00 >9,00
• Kronisk sjukdom	>					

Hälsokurvan						
Fysisk aktivitet    Tobak    Årtlighet, diabetes    Midja-Stuss-kvot    Kronisk sjukdom Mat    Livssituation    Årtlighet, Hjärt-Kärl-sjd    Blodtryck Alkohol    Psyisk ohälsa    BMI    Kolesterol						
Välj tidsperiod OBS: Under tidsperioder är kurvan uppskattad beroende på den information du har lämnat in, och blir mer lik verkligheten desto noggrannare du har fyllt i.			Låg risk ← → Hög risk 1      2      3      4			
▲ Fysisk aktivitet	>	kcal /vecka	>2000	1000-2000	500-999	<500
▲ Mat	>	Kost-poäng	3-5	6-9	9-11	

Hälsokurvan						
Fysisk aktivitet Min information Aktiva minuter Lägg till kategori Mina mål Se mina mål Skapa nya mål Påminnelser						
Historik    < Nov 2021 >    Schemalägg						
M	T	O	T	F	L	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					





Digital Tvilling  
simulering

aug 2021

T uppläst text

Digital Tvilling  
simulering

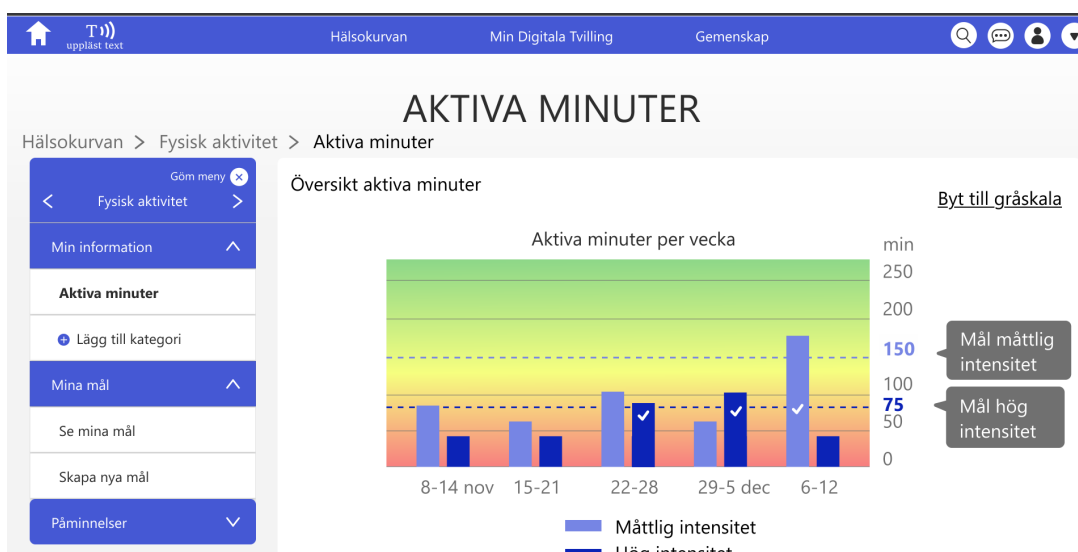
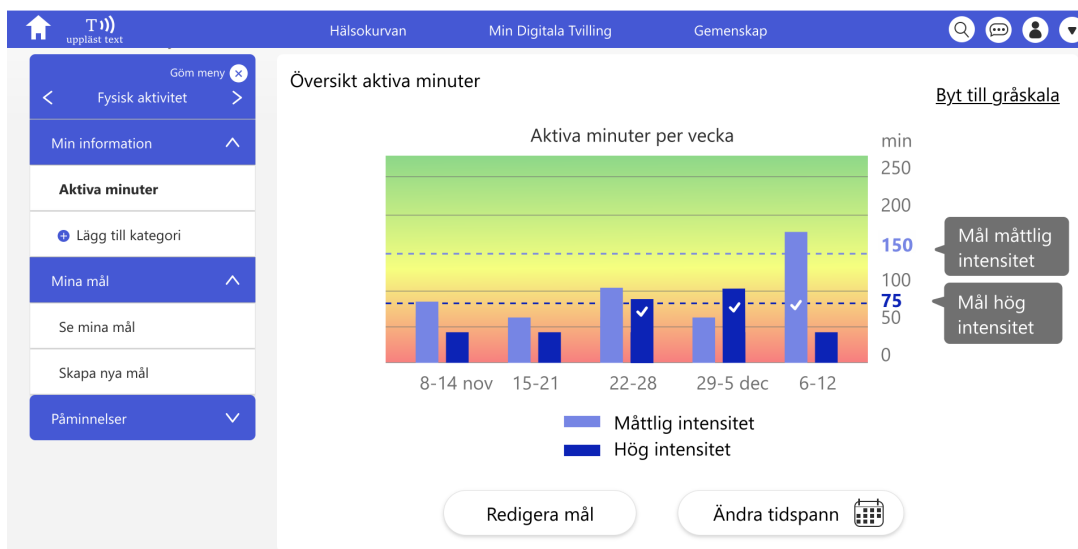
nov 2021

Uppspelningshastighet

Mer information

Läs mer om fysisk aktivitet och fördelarna med det.

<https://www.1177.se/Ostergotland/liv--halsa/>





uppläst text    Hälsokurvan    Min Digitala Tvilling    Gemenskap

## MIN DIGITALA TVILLING

Göm meny

**Min Digitala Tvilling**

Digital Tvilling ^

Uppdatera manuellt

Ladda upp information

**Information** ^

Hur fungerar tvillingen?

Frågor och svar

### Framtida möjligheter

Mål som uppnås    Vad du kan se    Vad du gör    Välj tidsperiod

Digital Tvilling simulering

uppläst text    Hälsokurvan    Min Digitala Tvilling    Gemenskap

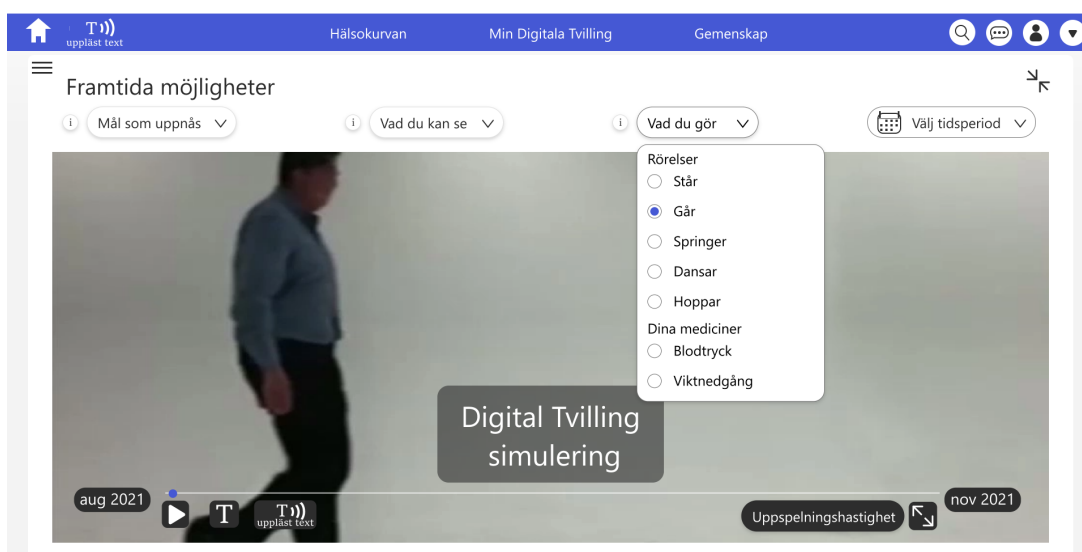
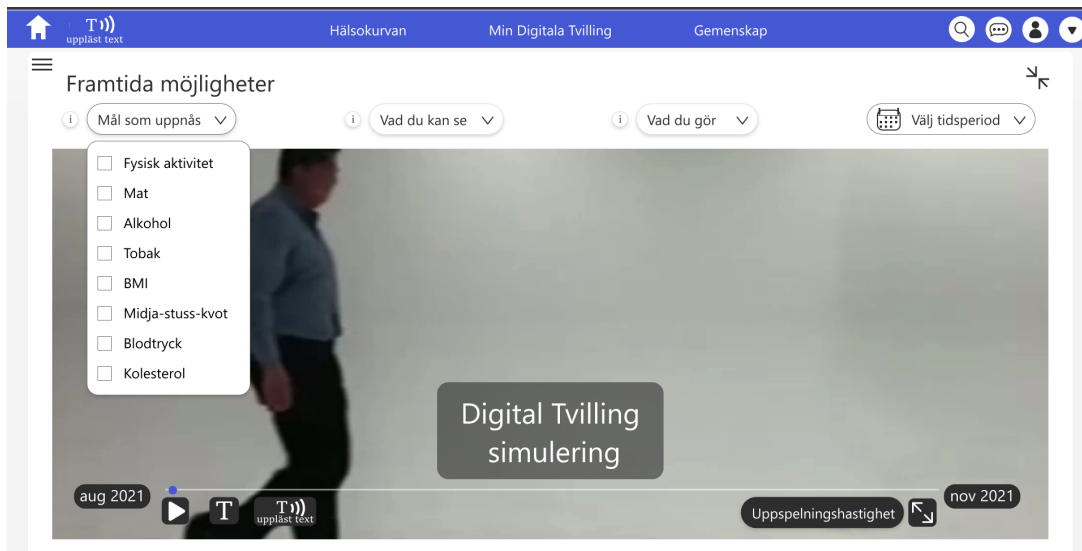
### Framtida möjligheter

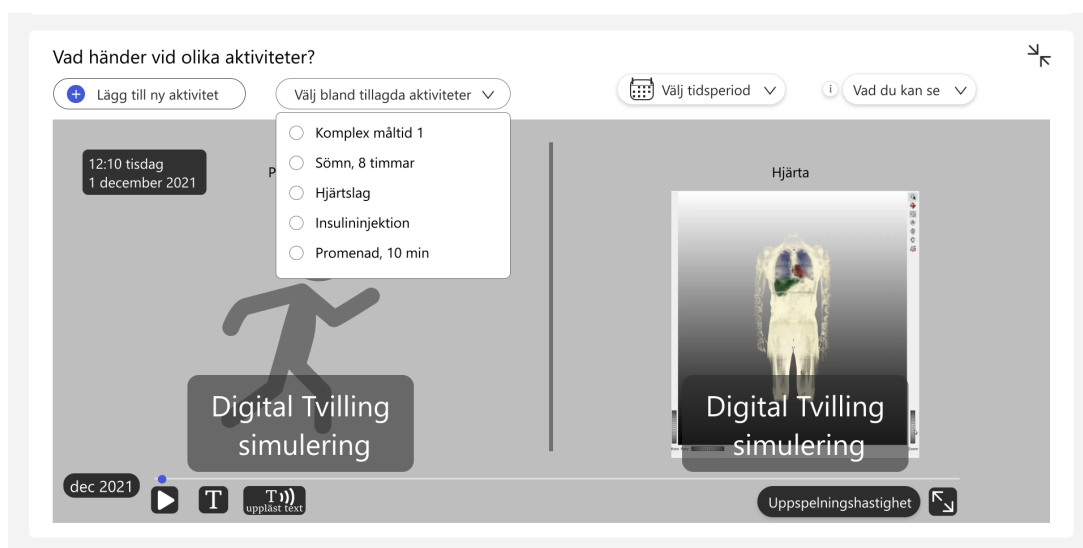
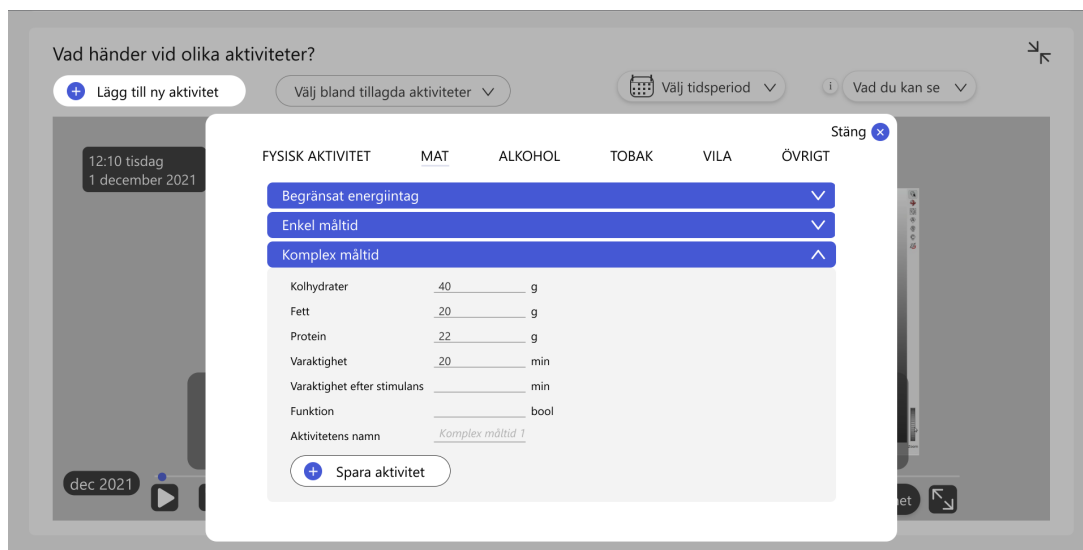
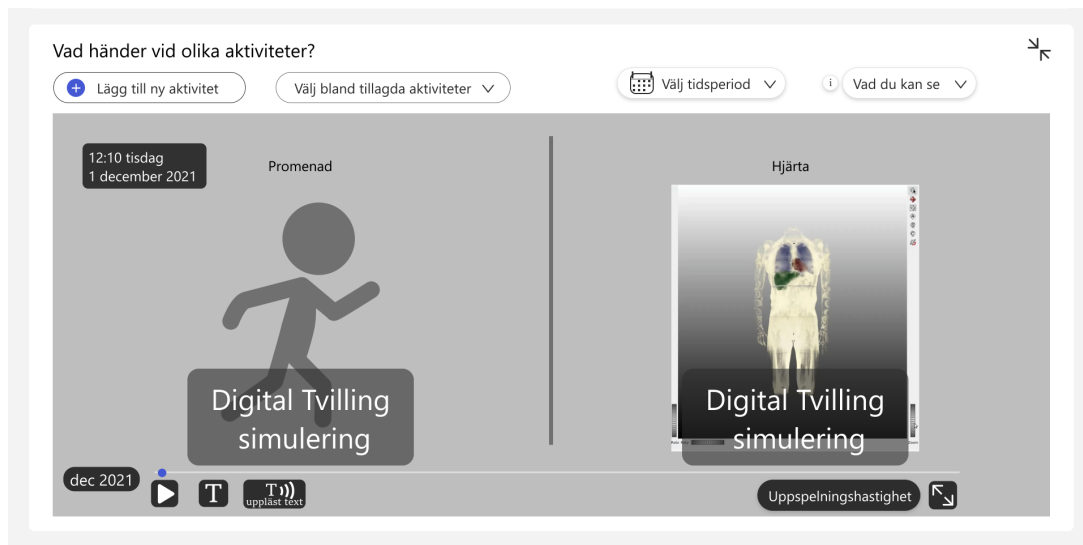
Mål som uppnås    Vad du kan se    Vad du gör    Välj tidsperiod

Digital Tvilling simulering

aug 2021    Uppspelningshastighet    nov 2021







Vad händer vid olika aktiviteter?

+ Lägg till ny aktivitet    Välj bland tillagda aktiviteter

Välj tidsperiod    Vad du kan se

12:10 tisdag  
1 december 2021

Promenad

Digital Tvilling  
simulering

dec 2021

Uppspelningshastighet

Hjärta

Digital Tvilling  
simulering

- Organ
- ☒ Hjärta (blodflöde)
- ☐ Hjärna (blodflöde)
- ☐ Hjärna (metabolism)
- ☐ Lever
- ☐ Mage
- ☐ Njurar
- ☐ Fettcell
- ☐ Fettväv

Hälsokurvan    Min Digitala Tvilling    Gemenskap

## GEMENSKAP

Göm meny

**Gemenskap**

Kontakt

Meddelanden

Vårdgivare

Grupper

Hitta grupper

Visa mina grupper

Hälsosam mat

Motionärer

Skriv någonting...

Skicka

Freja K. 12:10

Härlig lunchpromenad i solen!

Distans 1,5 km    Tid 20 min    Hastighet 13:20 min/km    2 nya rekord

Gilla    Kommentera

Händelser

Göm

Leo    William    Alexandra    Johanna

Nya framsteg

Tea H.  
100 minuter träning på en vecka  
Gilla    Kommentera

Hampus K.  
150 minuter träning på en vecka  
Gilla    Kommentera

Ylva R.  
2 mål nådda förra veckan  
Gilla    Kommentera

Se mer

Motionärerna

Inställningar

Hantera vänner

Hantera delning

Gilla    Kommentera

Karl Svensson 18:30

Hemlagad sushi istället för pizza ikväll, det var riktigt gott!

1 nytt rekord

Wow

Gilla    Kommentera



# User Test Answers



Figure C.1: Level of endorsement for item 1 for each participant number.



Figure C.2: Level of endorsement for item 2 for each participant number.



Figure C.3: Level of endorsement for item 3 for each participant number.

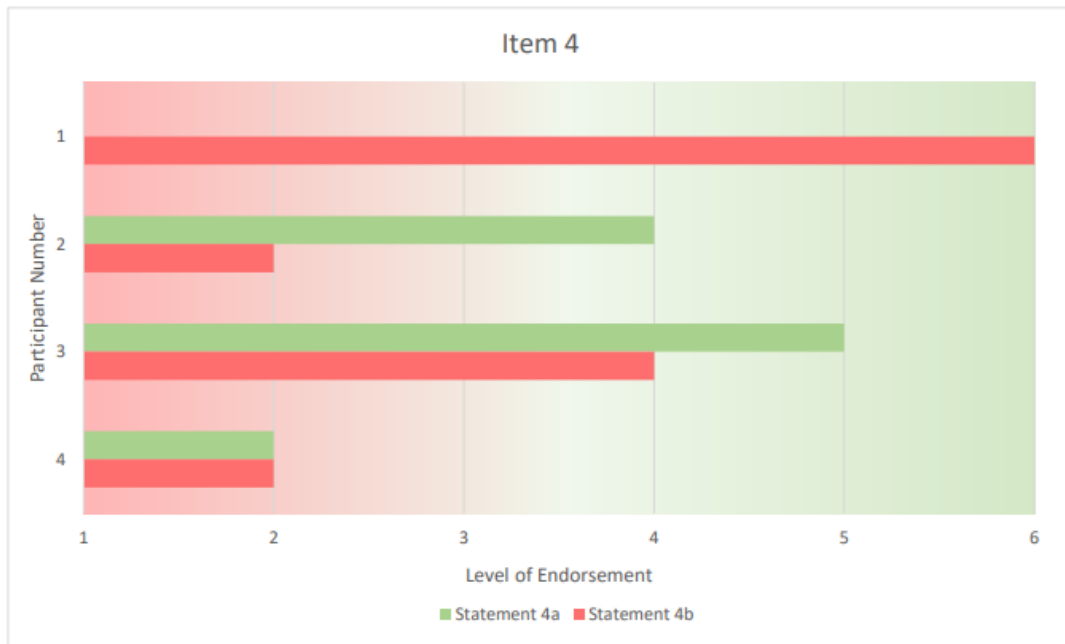


Figure C.4: Level of endorsement for item 4 for each participant number.



Figure C.5: Level of endorsement for item 5 for each participant number.



Figure C.6: Level of endorsement for item 6 for each participant number.